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OIL POLLUTION SOURCE IDENTIFICATION

M. Lieberman

Edison Water Quality Research Laboratory
Edison, New Jersey

February 1973

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Oil Pollution Source Identification

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OIL SPILL SOURCE IDENTIFICATION.

Lieberman, M.

EPA Project
15080 HDL

Esso Research and Engineering Company,
Government Research Division
Florham Park, New Jersey

68-01-0058

Environmental Protection Agency report
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Technology Series

Five different crude oils, two residual fuel oils (No. 4 and No. 5) and one distillate fuel oil (No. 2) were subjected to simulated weathering in the laboratory. Samples were weathered for 10 and 21 days at 55 and 80ºF, under high and low salt water washing rates. "Weathered" and "unweathered" oil samples were analyzed by low voltage mass spectroscopy (polynuclear aromatics), high voltage mass spectroscopy (naphthenes), gas chromatograph (n-paraffins), emission spectroscopy (nickel/vanadium), X-ray total sulfur and Kjeldahl total nitrogen techniques.

Several compound indices were adequately stable toward simulated weathering to discriminate between like and unlike pairs of oils. Discriminant function analysis was used to select the best compound indices for the oils used.

Using these indices, weathered and unweathered samples were correctly paired with high statistical confidence. (EPA)

*Oil Spills, *Pollutant Identification, *Chemical Analysis, *Correlation Analysis, *Weathering, Gas Chromatography, Mass Spectrometry, Tagging, Water pollution

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M. Lieberman

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EPA-R2-73-102
February 1973

OIL POLLUTION SOURCE IDENTIFICATION

By

M. Lieberman

Contract No. 68-01-0058
Project 15080 HDL

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ABSTRACT

A study was conducted to evaluate and develop a method for the identification of sources of oil pollution. The method is based on the comparison of certain stable chemical indices present in unweathered suspect oil pollution sources and the weathered pollution sample.

Five different crude oils, two residual fuel oils (a No. 4 and a No. 5 oil) and one distillate fuel oil (a No. 2 oil) were subjected to simulated weathering in the laboratory. Samples were weathered for 10 and 21 days at 55 and 80°F, under high and low salt water washing rates. "Weathered" and "unweathered" oil samples were analyzed by low voltage mass spectroscopy (polynuclear aromatics), high voltage mass spectroscopy (naphthenes), gas chromatograph (n-paraffins), emission spectroscopy (nickel/vanadium), X-ray total sulfur and Kjeldahl total nitrogen techniques.

Several compound indices were found to be stable after laboratory simulated weathering and showed the ability to help discriminate between pairs of oils used in the study. Discriminant function analysis was used to select the best compound indices for distinguishing among the oils used in the study. These included:

$$\frac{V}{Ni} \quad \left[\frac{\Sigma \text{Paraffins}}{\Sigma(P + N)}\right] \quad \left[\frac{\Sigma 5 \text{ Ring Naphthenes}}{\Sigma(P + N)}\right] \quad \left[\frac{nC_{20}}{\Sigma \text{nParaffins}/{}^{20}_{40}}\right]$$

$$\left[\frac{\Sigma 1+2 \text{ Ring Naphthenes}}{\Sigma 5+6 \text{ Ring Naphthenes}}\right]$$

These indices provided a means of clearly distinguishing among the oils used in the study with a high degree of statistical confidence. A procedure for applying the developed oil spill identification system is described.

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SECTION 1

CONCLUSIONS

1. It is possible to use certain specific ratios of chemical compounds present in the crude oils and oil products to distinguish (with very high statistical confidence) among any possible pairs of these oils, even after extensive simulated weathering in the laboratory.

2. The chemical fingerprint indices used to discriminate between all pairs of the oils used in the program were unaffected by laboratory simulated weathering.

3. The methodology and technology used to make the discrimination will be applicable to other oils. However, the fingerprint indices used to discriminate between pairs of oils used in the program are specific for the present study; their general applicability to other oils has not as yet been established.

4. Further studies are required to test the system on other oils with different physico-chemical properties and to test the system in a real marine environment.

SECTION 2

RECOMMENDATIONS

Studies conducted under EPA Contract No. 68-01-0058 utilized only laboratory simulated weathering of specific oil samples. It was not within the scope of the program to evaluate real marine weathered samples. It is recommended that the oil spill identification system, developed in the present program, be applied to samples which have been weathered in the real marine environment. The evaluation of real marine weathered samples is required to determine the effects of two weathering phenomena which could not be closely simulated in the laboratory:

- The huge ratio of water to oil film occurring in the ocean.
- The bacteriological effects in the ocean.

The present EPA program was also conducted with a limited number of samples - 5 crude oils and 3 fuel oils. These oils were selected: (a) to be representative of common types which are shipped in U.S. waterways, and (b) to have one pair of oils which originate from the same general area (Venezuela). It is recommended that the oil spill identification system developed in this program be expanded to other oils which are representative of all major generic chemical types so that the feasibility of the system may be generalized.

It is also recommended that the system be applied to crudes or products which are of very close origin, e.g., production from neighboring wells in the same field or from the same field, but differing in time of removal from the ground.

The ability to distinguish between heavy non-blended residual fuels and crudes will be very useful in oil spill identification. The present EPA-sponsored program considered the generic distinction between residual fuels and crudes, but not as a main objective. It is recommended that further work be conducted to better adapt the developed oil spill identification program to make this distinction. This would best be done by including some n-paraffin tags below n-C_{20}.

Finally, it is recommended that the system be tested with a number of "known" real spill situations, using samples covering as wide a range of marine salt and fresh water environments as possible.

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SECTION 3

INTRODUCTION

In recent years, this nation has become increasingly aware of the potential harmful effects posed by the spillage of oils into salt and fresh waters. Oil spills have, in many cases, been damaging to property and commercial interests and may also adversely affect many forms of aquatic life. Although many devices and techniques have been developed to contain, control and disperse spilled oil, clearly the best solution to the oil spill problem is to prevent them from occurring.

Legislation passed by Congress and international conventions adopted by many countries participating in the United Nations Intergovernmental Maritime Consultive Organization (IMCO) have provided for harsh penalties for deliberate and negligent accidental oil spills; but in order for these penalties to be effective deterrents against potential violators of the law, the Federal Government must have the capability to enforce the law--to effectively prosecute suspects. One most important piece of evidence that is needed for effective prosecution is a method to positively identify the source of the oil spillage.

To this end, the Environmental Protection Agency, Office of Research & Monitoring, awarded the Esso Research and Engineering Company Government Research Laboratory, Contract No. 68-01-0058, "Oil Spill Source Identification".

The primary objective of this contract was to develop a system to positively identify unknown sources of oil pollution. The developed system had to be able to clearly identify an unknown spilled oil and had to be fully effective under a wide range of environmental conditions with minimal sensitivity to weathering. The developed system also had to have a high detection sensitivity and had to be practical to implement. Several previous attempts have been made to develop oil spill identification systems. These include two general approaches--active and passive tagging. In the "active tagging" approach, a special chemical or substance is deliberately added (in different forms) to different oils to uniquely identify each. Such a system is extremely difficult to implement and causes potential refinery contamination problems.

The passive tagging system utilizes the inherent chemistry of oils and does not require the addition of an external substance. Suspect oils are compared with a spill sample utilizing certain chemical indices present in oils and unique to each.

The Esso system proposed and developed under EPA Contract No. 68-01-0058, is a passive tagging system (i.e., one which is based on the inherent chemical composition of oils only and not on the addition of some external chemical or material) which employs the techniques of mass

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spectroscopy, gas chromatography, emission spectroscopy, X-ray total sulfur and Kjeldahl total nitrogen analyses to resolve oil spill samples into stable "chemical fingerprints." Data for the chemical fingerprints used in the system are derived from:

- High molecular weight n-paraffins
- Polynuclear aromatics
- Naphthenes
- Bulk V/Ni and S/N contents.

The work conducted under this EPA contract was aimed at determining which specific "fingerprint" indices in these families of components would be the best for positive identification. This was done through the analysis of a set of oil samples subjected to controlled simulated weathering experiments.

In this final report, the methodology, techniques, and results of this EPA sponsored study on "Oil Spill Identification" are described. In Section 5, the experimental phase of the study is described, including the selection of test oil samples, a description of the weathering apparatus and tests and a discussion of the weathering variables.

Sample analysis is described in Section 6 including an overall sample separation and analysis flowsheet, a description of the analytical unit processes involved and a discussion of some analysis problems encountered. Supplemental analyses, which provided background information on weathering effects, are also described.

Section 7 describes the steps involved in the development of the Esso oil spill identification system, including the preliminary selection of fingerprint indices, final selection of preferred fingerprint indices, the techniques used to develop the fingerprint data and a summary of the steps required in the application of the system. General effects of weathering are described in Section 8.

SECTION 4

PROGRAM OBJECTIVES

Overall Objective - To develop a passive tagging system to positively identify the source of oil spills. The system should have the following characteristics:

A. Compatibility of tags with subsequent handling techniques (refining, marketing, etc.) or use.

B. Stability of tags over long periods in storage and when exposed to ambient air and water conditions.

C. Minimum effect of weathering on effectiveness of passive analytical techniques.

D. Capacity for a large coding vocabulary such that all oil stored or transported is unequivocally related to the persons responsible for preventing its spillage.

E. High sensitivity to detection and negligible effect of potentially interferring substances.

F. Low cost and operational simplicity of both the tagging operation and analytical procedures.

The technical objectives are as follows:

A. To develop the most stable and discriminating passive tag compound indices for a given oil spill identification situation.

B. To develop the required data treatment methodology for the system.

C. To develop the best analytical separation and processing scheme for the system.

D. To determine any effects of weathering.

E. To identify any problem areas and limitations of the system.

SECTION 5

EXPERIMENTAL PROGRAM

The experimental phase of the oil spill identification program included the following components:

- Selection of test samples.
- Selection of weathering variables.
- Design of weathering apparatus.
- Weathering tests.

These are discussed and/or described in the following paragraphs.

5.1 Selection of Test Samples

Since only a limited number of samples could be used in the present program (due to constraints of program time and cost), those oil samples chosen for study were chosen to be representative of the most probable sources of pollution to the United States and vicinity. The primary criterion used for selection was, thus, volumes transported on U.S. waterways.

Gasoline and distillate fuel oils are the petroleum products with the largest volumes shipped on U.S. waterways (7). These products do not persist on the sea because of their high volatility. However, they may contain certain highly soluble components, and thus present a potential pollution hazard. Oil products which contribute to the next largest volume of transport are crude oils and residual fuel oils. These are much less volatile, tend to persist much longer after spillage and present a much greater ecological threat. Ship bilge water is also a potential large volume spill. Although we originally intended to include a bilge water sample in our test, we later found it impractical to study, primarily because of the dilute nature of the samples obtained.

The origin of the crude oils selected for test was also based on volume transport. Data from the April 1970 U.S. Petroleum Industry Annual Statistical Review showed the following distribution:

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TABLE 1

BASIS OF CRUDE OIL SAMPLE SELECTION - MOVEMENT OF CRUDE PETROLEUM TO THE UNITED STATES (1969) (7)

Exporting Country	Imports to the United States (Thousands of Barrels)
Venezuela	111,722
Libya	48,862
Indonesia	32,271
Nigeria	17,958
Neutral Zone	15,864
Colombia	15,551
Iran	15,306
Egypt	14,778
Saudi-Arabia	12,665
Kuwait	12,539
Other	13,035
Total	310,551*

---

* Excludes imports from Canada.

Crude oil samples from the four leading import countries were selected; two different crude oil samples from Venezuela were selected because of its particularly high level of export to the U.S. Two crudes with a close proximity of origin were deliberately selected to test the ability of the developed identification system to distinguish closely related oils. A summary of the crude and refined oil products used in this study is given below in Table 2.

TABLE 2

OIL SAMPLES SELECTED FOR EPA PROGRAM

Sample No.	Sample Type	Oil Field	Location
1	Crude oil	Tia Juana	Venezuela
2	Crude oil	Lago	Venezuela
3	Crude oil	Grande Isle	Indonesia
4	Crude oil	Nigeria	Nigeria
5	Crude oil	Zuitina	Libya
6	No. 2 Heating oil	Refined and formulated from Venezuelan stock	
7	No. 4 Fuel oil		
8	No. 5 Fuel oil		

5.2 Selection of Weathering Test Variables

Several environmental factors were considered for the evaluation of any effects of weathering on sample chemical fingerprint indices. These included type of water, temperature, degree of water washing of the oil, exposure to sunlight, wind effects and contact time.

The time that an oil sample is exposed to the environment (contact time) is important in its measure of the rate of weathering. The effect of contact time was incorporated into the study by using a sufficiently large sample for test such that portions could be removed at specific intervals.

Temperature was also considered an important factor in that it affects the rate of weathering (evaporation, oxidation, etc.) and was thus used as an experimental variable.

The extent of water washing of the oil samples was considered very important. A high washing level increases the leaching rate of partially water soluble components from the oil sample and increases the tendency of the oil sample to emulsify (which further accelerates leaching) by providing a higher oil-H_2O interfacial area. Water-oil contacting may also control chemical processes which are diffusion limited. Thus, the level of water washing was selected as the second weathering variable for our experimental tests.

Wind speed and sunlight intensity were also considered important environmental factors. Wind speed can greatly affect the rate of evaporation of volatile components and ultraviolet light from the sun can effect chemical oxidation changes. However, the intensity of these weathering factors changes substantially in nature in short time intervals and their use as experimental variables, though of interest, was considered to have lower practical value. It was thus decided to provide for the simulation of sunlight and wind in our experimentation but not to use them as experimental weathering variables.

Consideration was also given to the type of water to use in our tests. Crude oil and residual fuel oils which present the most persistent forms of pollution, are transferred primarily by salt water routes; fresh water routes are primarily used for refined, more volatile oil products such as gasoline and kerosene and generally contain considerably less total volumetric oil traffic than salt water. Although it was originally planned to run a select number of samples in fresh water in addition to a complete set of experiments in salt water, it was found that the program schedule would not accommodate the fresh water tests. Thus, all tests were conducted using salt water. All the salt water used in this study was obtained from the New Jersey shore, Manasquan Inlet (Point Pleasant side) at high tide.

The experimental variables and levels of test of the selected variables are summarized below in Table 3.

TABLE 3

SUMMARY OF EXPERIMENTAL WEATHERING VARIABLES

Experimental Variables	Levels of Test
Time	10 days, 21 days
Temperature	55°F, 80°F
Water Washing	High, Low

The responses used to determine the nature and magnitude of any effects of these variables were selected compound concentration ratios of candidate fingerprint tags. Compound indices that showed no or minimal change during weathering and which had the best discriminating capability for the oils tested in this program were used to develop the complete fingerprint functions. The data obtained from the weathering experiments and the techniques used to develop the chemical fingerprint functions are presented in Section 7 of this report. The apparatus used to run the weathering experimnets is described in the following paragraphs.

5.3 Design of the Weathering Apparatus

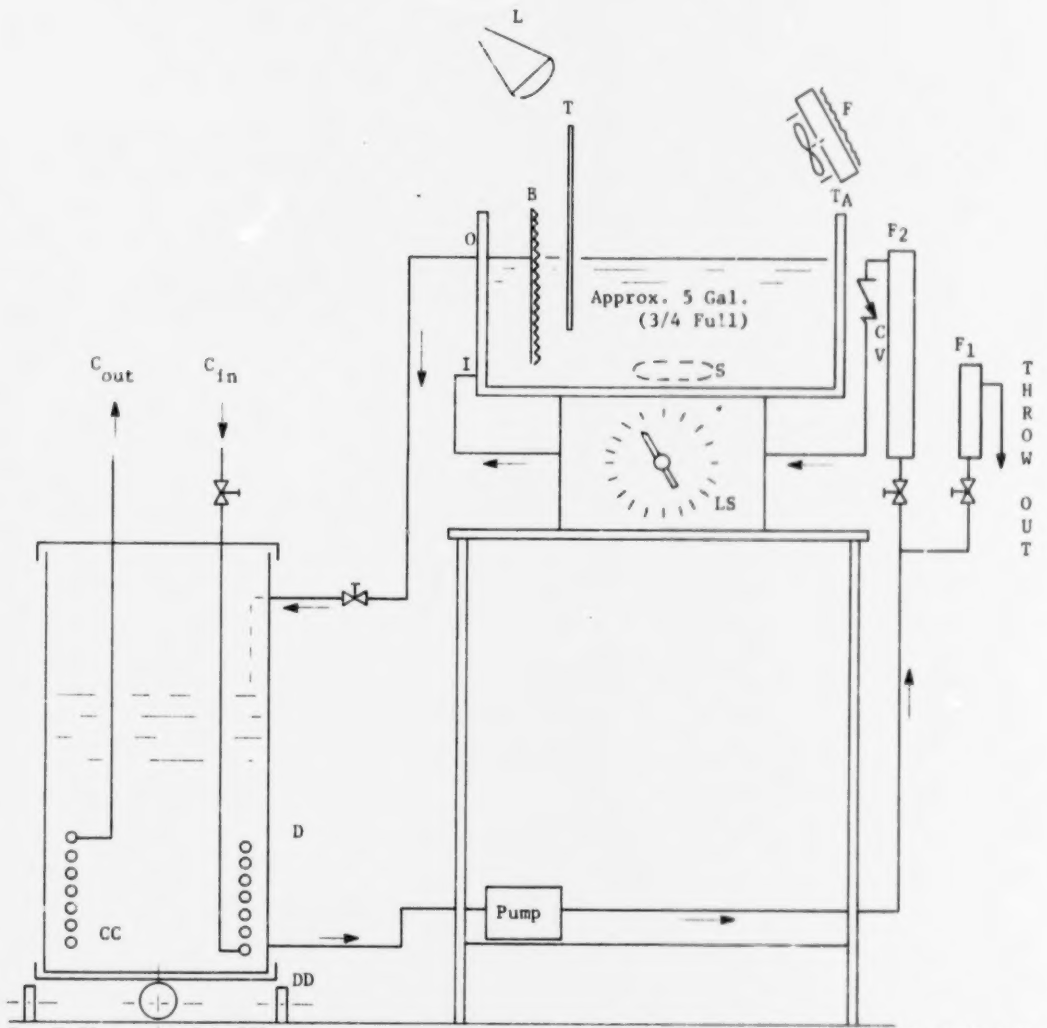
The environmental simulation test facility used in our study is depicted in Figure 1 and illustrated schematically in Figure 2. The main function of this facility was to provide a means of simulating and controlling the environmental (weathering) variables being tested as well as other important environmental conditions which were fixed during the experiments. The main components of this facility included:

FIGURE 1

ENVIRONMENTAL SIMULATION TEST FACILITY

FIGURE 2

ENVIRONMENTAL SIMULATION TEST FACILITY SCHEMATIC


L
T
F
B
O
T_A
F_2
Approx. 5 Gal.
(3/4 Full)
C_{out}
C_{in}
I
S
C
V
F_1
THROW OUT
LS
D
Pump
CC
DD

B - Teflon coated baffle
C_{in}, C_{out} - Chilled water in and out
CC - Cooling coil (S.S.)
CV - Check valve
D - S.S. drum (55 gal.)
DD - Drum dolly

F - Fan, F_1 - 5 to 50 cc/min, F_2 - .3 to 60 GPM
I - Tangential inlet
L - Programmed on-off sunlamp
LS - Rotating magnetic stirrer
O - Overflow
T - Thermometer stirring magnet
T_A - Teflon coated tank
S - Stirring Bar

- A continuous water recirculation system.
- A reservoir (stainless steel drum) for holding the salt H_2O.
- A Teflon coated, baffled tank to hold the oil samples.
- A cooling coil refrigeration system to chill the salt H_2O.
- A Teflon coated magnetic stirrer.
- An ultraviolet lamp to simulate exposure to the sun.
- A fan to simulate wind currents.

Ten separate individual rigs of the type described in Figures 1 and 2 were used in this program. Each operated independently (except for the water chiller cooling coils which were connected in parallel to a water chiller).

In operation, salt water was continuously pumped from the stainless steel drum into the Teflon magnetic pump. In the Teflon coated tank, the water continuously "washed" the test oil sample and then was returned to the drum by gravity. An underflow baffle in the Teflon coated tank allowed the passage of water but prevented the oil sample (which remained on the H_2O surface) from leaving the tank. A Teflon coated bar, activated by a magnetic stirrer, provided additional mixing in the tank. Water cooling temperature (55°F) was maintained by means of the chilled water cooling coil immersed in the salt water reservoir drum for low temperature levels of test. High temperature (80°F) water was maintained by keeping the laboratory room temperature at 80°F.

A G.E. model 78 ultraviolet lamp was used to provide simulated sunlight to the oil samples.

Mounted to shine directly on the surface of each tank, the ultraviolet lamps were connected to a special electric timer circuit that provided two hours a day of lamp on time. At the selected distance of each lamp from the oil surface, this exposure time provided an ultraviolet dosage comparable to a cloudless full summer day in the mid-northern hemisphere.

A constant speed fan, mounted on each tank, simulated exposure to constant wind of about 15 mph. The weathering tests were conducted as described in the following paragraphs.

5.4 Weathering Tests

The weathering tests were conducted by establishing steady state conditions of salt-H_2O temperature, recirculation rate and magnetic stirrer speed and then adding a fixed quantity of the test oils to the salt H_2O in the Teflon coated weathering tanks. The sample size of oil used in each case (1000 cm^3) was large enough to allow two 50 cm^3 aliquot samples to be removed for analysis at two different times even after considerable evaporation of oil volatile components and leaching of soluble components had taken place. (It was later apparent that 500 cc would have been adequate but the original 1000 cc oil sample was maintained throughout the testing for uniformity.) Oil samples were taken from the same 5 gal. cans, which were thoroughly mixed before addition to the tanks.

As indicated earlier, a chilled H_2O unit provided refrigeration through a cooling coil immersed in each 55 gal. stainless steel drum. Salt water was maintained at 55 ± 5°F for the low temperature tests. A temperature of 80 ± 7°F was maintained throughout the high temperature tests by means of regulation of the laboratory ambient. No noticeable increase in surface oil temperature was detected (by a thermometer) when the 500 watt ultraviolet lamps were turned on for as long as two hours. Lamp heat was efficiently removed by the heat sink effect of the recirculating H_2O. Ultraviolet lamps were automatically turned on and off for two hours of each day by an electric timer.

High and low water mixing (washing of oil) conditions were regulated by three different experimental parameters:

	High MIX	Low MIX
Total Salt H_2O Volume	55 gals.	12 gals.
Salt H_2O Recirculation Rate	2-3 GPM	0.2-0.3 GPM
Teflon Stirrer	(200-500 RPM) approx.	25-50 RPM

Flow rates and stirrer speed were adjusted daily to maintain the desired levels.

Salt water concentration was periodically monitored by making specific gravity measurements. Both evaporation and condensation of H_2O took place, depending on the temperature of test and the temperature and humidity of the laboratory ambient air--i.e., on whether the test temperature was above or below the dew point of the ambient air.

Distilled H_2O and concentrated salt H_2O were periodically added to maintain constant volume and concentration of the salt H_2O throughout the test. However, the total volume and concentration adjustments required were always a negligibly small fraction of the total wash water present*.

Weathered oil samples were removed from the Teflon coated tank at 10 and 21-day intervals. For those oil samples which were below their pour point (55°F tests), the total sample removed for analysis was taken from several locations on the surface of the "immobile" oil. Two separate samples of each of the eight oil samples under test (about 25 cm^3 each) were sent to the mass spectroscopy-gas chromatography and emission spectroscopy laboratories, respectively. In addition to the weathered samples, portions of unweathered oil of each type under test were submitted for analysis. The analytical processing and separation of the oil samples evaluated in this study are described in the following section.

---

* Ambient H_2O vapor condensation at the onset of testing at the low temperature (55°F condition) was a problem. However, this problem was solved by keeping the laboratory air-conditioner on 24 hours/day.

SECTION 6

SAMPLE PROCESSING AND ANALYSIS

The weathered and unweathered oil samples evaluated during this study were subjected to an analytical processing scheme to obtain the necessary fingerprint data. Two samples were taken from each oil under study for each set of experimental conditions discussed in Section 5. One sample was used for nickel/vanadium analysis (emission spectroscopy), sulfur analysis (x-ray spectroscopy) and nitrogen analysis (Kjeldahl); the other sample was used for mass spectroscopy and gas chromatography. The M.S.-G.C. analysis required considerable sample processing and separation before these techniques could be applied. This processing is best described with reference to the sample analysis schematic depicted in Figure 3.

6.1 Removal of Water and Light Ends

Samples were first distilled in a glass still to remove any H_2O (which was always present with weathered samples) and to remove light ends with boiling points up to 400°F. Light ends were not considered reliable fingerprint indices and tended to make subsequent separation more difficult. They were, thus, removed in this preliminary distillation step.

6.2 Removal of Insolubles

The residue from the distillation step was then treated to remove insolubles. This generally follows procedure A of ASTM test D 893-69 for pentane insoluble materials. The procedure involved the following steps:

- Weighing the distillate residue to a tenth of a milligram.
- Adding 50 cm^3 of n-pentane.
- Centrifugation and decantation of the liquid.
- Repeat pentane addition, centrifugation and decantation, combining and saving both decanted washes.
- Weighing of the insoluble dried residue.

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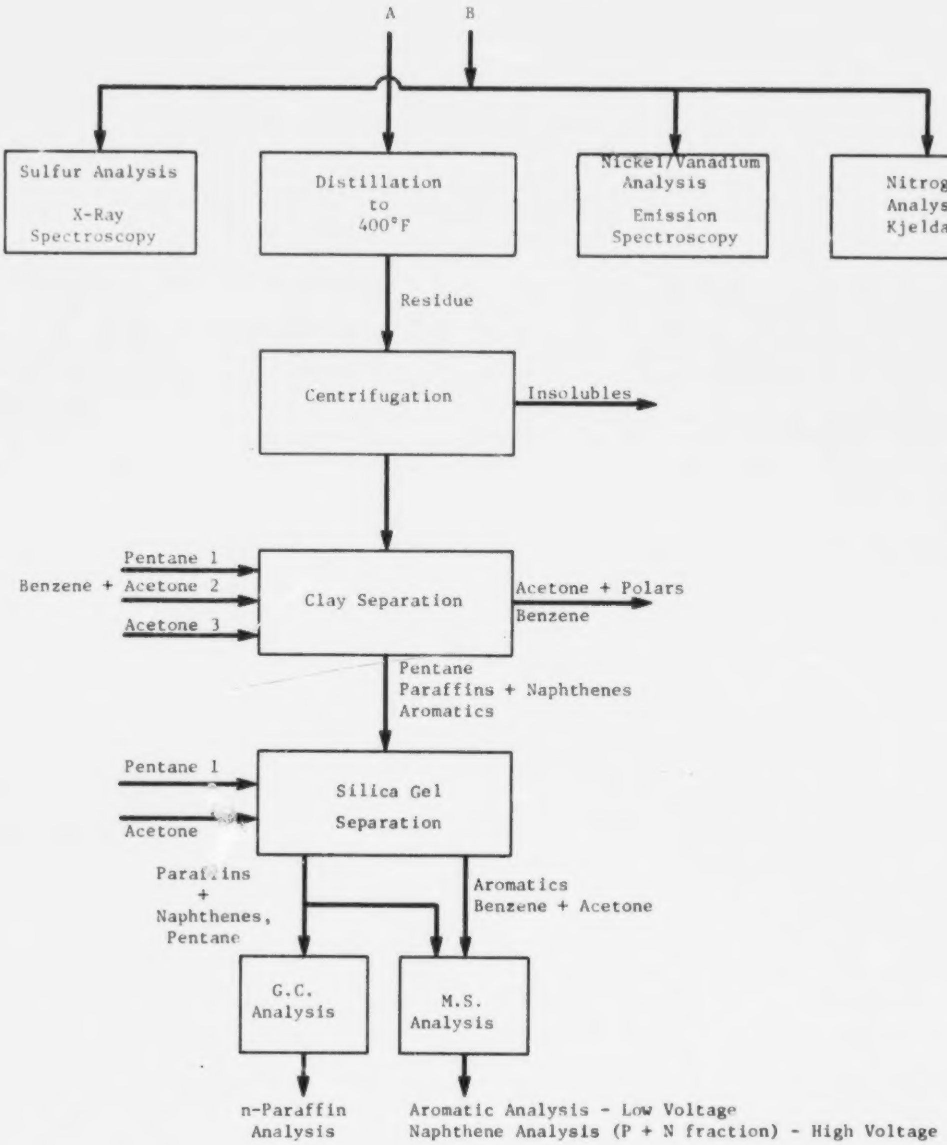
FIGURE 3

SAMPLE ANALYSIS SCHEMATIC


A
B
Sulfur Analysis
X-Ray Spectroscopy
Distillation to 400°F
Nickel/Vanadium Analysis
Emission Spectroscopy
Nitrogen Analysis Kjeldahl
Residue
Centrifugation
Insolubles
Pentane 1
Benzene + Acetone 2
Acetone 3
Clay Separation
Acetone + Polars
Benzene
Pentane
Paraffins + Naphthenes
Aromatics
Pentane 1
Acetone
Silica Gel Separation
Paraffins + Naphthenes, Pentane
Aromatics
Benzene + Acetone
G.C. Analysis
M.S. Analysis
n-Paraffin Analysis
Aromatic Analysis - Low Voltage
Naphthene Analysis (P + N fraction) - High Voltage

6.3 Removal of Polar Compounds - Clay Separation

After the insolubles are removed, the sample dissolved in n-pentane from the above procedure is fed to a clay separation column to remove polar compounds. The clay column polar compound separation follows ASTM procedure D 2007-65T which involves the following important steps:

- Prewetting of clay (attapulgus clay 30-60 mesh containing 11-13% H_2O) column with 25 cm^3 of n-pentane.
- Adding the sample of n-pentane containing dissolved materials (from insolubles removal).
- Addition of 8 separate 10 cm^3 portions of n-pentane (which were used to wash the sample flask) to the column. The pentane eluted from the clay column will contain the sample saturate compounds (paraffins + naphthenes) and aromatics.
- Addition of 100-125 cm^3 of 70% benzene-30% acetone to the clay column.
- Addition of 25 cm^3 of acetone.

The eluted acetone-benzene and acetone solvents will contain the polar fraction of the sample. The polar compounds were not considered as candidate chemical fingerprints because of their high solubility.

6.4 Separation of Aromatics From Saturates - Silica Gel Separation

The elution from the clay separation step (containing saturate and aromatic fractions of the original sample) is stripped of its pentane and is then fed to a silica gel column to separate out the aromatics. The silica gel separation involves the following steps:

- Dissolution of the saturate-aromatic cuts (after pentane stripping) from the clay separation in 10 cm^3 of n-pentane.
- Prewetting the column with 10 cm^3 of n-pentane.
- Addition of the sample to the column followed by 8 replicate 10 cm^3 portions of n-pentane to elute the saturate fraction.
- Addition of 75-100 cm^3 of acetone to elute the aromatics.

Typical material balance data obtained from the processing of samples used in this study are presented in Table 4. Additional material balance data on sample processing may be found in Appendix A.

TABLE 4

TYPICAL MATERIAL BALANCE DATA FROM SAMPLE SEPARATION PROCESSING(1)

Oil Type	Paraffins + Naphthenes	Weight % of Sample			
		Aromatics	Polars	Pentane Insolubles	Σ Fractions
Tia Juana Medium Crude Oil	46.0	21.6	19.3	9.0	95.9
Lago Crude Oil	39.8	21.8	24.7	15.5	101.8
Grande Isle Mix Crude Oil	73.0	16.1	12.3	1.2	102.6
Nigerian Crude Oil	61.2	20.7	10.6	1.0	93.5
Zuitina Crude Oil	66.1	12.1	15.2	3.1	96.5
No. 2 Heating Oil	49.7	46.6	0.0	0.2	96.5
No. 4 Heating Oil	63.2	26.2	8.6	1.0	99.0
No. 5 Heating Oil	64.2	20.4	12.1	5.8	102.5
Replicate Tia Juana Medium Crude Oils	48.2	19.5	18.4	10.9	97.0
	47.7	20.8	20.4	9.4	97.9
	47.4	18.6	21.5	10.9	98.4

---

(1) Data based on unweathered samples. See Appendix A for complete material balance data.

6.5 Separation Mass Spectroscopy - Gas Chromatography Analysis

The final result of the column separation is a saturate fraction (paraffins + naphthenes) and an aromatic fraction which were analyzed as follows:

Saturate Fraction	Aromatic Fraction
• Mass spectroscopy* for naphthene type analysis	Low voltage mass spectroscopy+
• Gas chromatography for n-paraffin analysis	

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* Hood, A., O'Neal N. J., Advances in Mass Spectroscopy, J. D. Waldron Ed., 1959, p. 175.

+ Lumpkin, H. E. Anal. Chem. 30, 321 (1958).

The mass spectrometer used for both naphthene type analysis and aromatic analysis (low voltage setting) was a CEC Model 21-103. The gas chromatograph used for the n-paraffin analysis of the saturate cut was a Perkin Elmer Model 900. The column used with the G.C. was a 7-1/2' x 1/8" D stainless steel unit packed with 2 weight % SE 30 on Chromasorb G. Programmed temperature operation was started at 60°C and increased at a rate of 8°C/min. to 350°C.

The mass spectrometer was coupled to a computer which provided aromatic and naphthene analysis, examples of which are illustrated in Tables 5 and 6 respectively. Gas chromatographic results were hand calculated with the aid of a planimeter.

6.6 Analytical Problems

During the course of the program, several analytical problems were encountered and solved.

In the initial attempt to process the weathered and unweathered oil samples, no provision was made for removal of insolubles (asphaltenes) and polar compounds. The presence of these materials caused erratic silica gel separations with poor material balance. The incorporation of the insolubles and polar removal steps prior to silica gel separation solved this problem.

The presence of salt H_2O with weathered oils also caused erratic column separation performance. This problem was alleviated by subjecting the sample to distillation (to 400°F) prior to a column separation. Loss of volatile oil components during distillation presente no problem as they did not constitute candidate fingerprint compounds.

Finally, in the originally proposed analytical scheme for this study, the individual n-paraffins were to be analyzed by mass spectroscopy (simultaneously with the naphthene analysis). However, it was found that the precision of the n-paraffin analysis, as provided by the CEC Model 21-103 mass spectrometer, was not acceptable for this study. The gas-chromatographic analysis described earlier was found to be more precise for the n-paraffin analysis and was thus employed in the final analysis train.

6.7 Supplementary Analysis

The analysis scheme described in the previous paragraphs was aimed at providing the necessary data to develop and select stable chemical fingerprint indices. This was the objective of the program. However, in order to evaluate some general effects of weathering (on sample constituents not used as chemical fingerprints) some additional analyses were conducted on a few weathered and unweathered whole oil samples (without using any separation processing). These included:

- A gas chromatographic distillation which was used to estimate the effects of evaporation.

TABLE 5

M.S. COMPUTER PRINT-OUT OF AROMATIC ANALYSIS(1)(2)

```
 METHOD=  2007
1 RUN NUMBER 18106                           3/20/72
ANALYSIS OF AROMATICS - LOW VOLTAGE MS METHOD
SERIES      CNH2N-6      CNH2N-8     CNH2N-10     CNH2N-12     CNH2N-14     CNH2N-16     CNH2N-18
CARBON NO.
C 6          0.00                           Unweathered Tia Med
C 7          0.09
C 8          0.25
C 9          0.35         0.16         0.02
C10          0.27         0.22         0.07         0.00
C11          0.14         0.21         0.10         0.03
C12          0.17         0.18         0.11         0.21         0.01         0.01
C13          0.30         0.16         0.11         0.56         0.07         0.03
C14          0.38         0.20         0.13         0.71         0.28         0.14         0.14
C15          0.49         0.28         0.22         1.06         0.62         0.35         0.53
C16          0.76         0.50         0.37         1.78         0.84         0.47         0.89
C17          1.12         0.76         0.46         1.79         0.89         0.48         0.83
C18          1.34         0.92         0.52         1.36         0.87         0.55         0.60
C19          1.36         0.96         0.55         1.06         0.83         0.67         0.56
C20          1.35         1.05         0.59         0.89         0.82         0.67         0.59
C21          1.28         1.10         0.61         0.81         0.81         0.62         0.57
C22          1.22         1.16         0.65         0.76         0.77         0.58         0.51
C23          1.12         1.09         0.63         0.68         0.69         0.54         0.49
C24          1.08         1.05         0.64         0.63         0.63         0.49         0.44
C25          1.05         1.01         0.63         0.59         0.60         0.46         0.42
C26          1.01         0.99         0.63         0.56         0.58         0.45         0.41
C27          0.95         0.93         0.62         0.55         0.55         0.43         0.41
C28          0.86         0.85         0.59         0.50         0.51         0.42         0.38
C29          0.75         0.77         0.55         0.46         0.47         0.39         0.35
C30          0.67         0.70         0.50         0.42         0.42         0.34         0.31
C31          0.59         0.63         0.43         0.36         0.36         0.29         0.27
C32          0.51         0.56         0.39         0.32         0.33         0.27         0.24
C33          0.45         0.49         0.36         0.28         0.29         0.24         0.21
C34          0.40         0.44         0.31         0.25         0.25         0.21         0.19
C35          0.34         0.33         0.00         0.22         0.23         0.18         0.16
C36          0.30         0.32         0.25         0.19         0.20         0.16         0.15
            -----        -----        -----        -----        -----        -----        -----
  TOTALS    21.05        18.20        11.16        17.17        13.04         9.60         9.75
```

---

(1) Unweathered Tia Juana Medium Crude Oil used in example.

(2) Includes small amounts of aromatic sulfur compounds which are not separately resolved by the CEC Model 21-103 Mass Spectrometer.

TABLE 6

M.S. COMPUTER PRINT-OUT OF NAPHTHENE ANALYSIS *

```
 METHOD=  2012
1 RUN NUMBER 13089                          3/15/72
 OIL SPILL USING FIXED C24 MATRIX
          SHELL PARAFFIN-NAPHTHENE TYPE ANALYSIS

                              WT.PCT.

 PARAFFINS                     33,26
 1-RING NAPHTHENES             24.29
 2-RING NAPHTHENES             19.13
 3-RING NAPHTHENES             11.57
 4-RING NAPHTHENES              7.10
 5-RING NAPHTHENES              2.96
 6-RING NAPHTHENES              1.66
 MONO-AROMATICS                 0.00
 TOTAL                        100.00
AVERAGE CARBON NUMBER    21.85
```

---

* Unweathered Tia Juan Medium Crude Oil used in example.

- An infrared scan to estimate the effects of oxidation.

The gas chromatographic distillation followed the ASTM procedure D-2887 using a 2' x 1/4"D column containing WC-98 on Chromasorb.

The I.R. analysis was run on the neat oil samples using no solvent. A Beckman IR-8 unit was used with a 0.110" cell and a slow scan setting. The results of the supplementary weathering study, using G.C. distillation and I.R. analysis, are presented in Section 8 of this report.

SECTION 7

OIL SPILL IDENTIFICATION SYSTEM DEVELOPMENT

In this section of the report, the methodology used to develop the Esso passive tagging oil spill identification system is presented. This includes the following:

- Preliminary Selection of Fingerprint Indices.
- Development of Final Fingerprint Indices and Functions Using Descriminant Function Analysis.
- Estimation of the Probability of Oil Misclassification Using the Discriminant Function.
- Estimation of Confidence Levels for Oil Classification Using Bonferroni "t" Statistics.
- Summary of Application of System.
- Discussion of System Limitations.

These are discussed, in turn, in the following paragraphs.

7.1 Preliminary Selection of Fingerprint Indices

Data for the preliminary selection of candidate fingerprint indices for this system were obtained from the application of the following analytical techniques to the program test samples:

- Low voltage mass spectrometric analysis of polynuclear aromatic hydrocarbons.
- High voltage mass spectrometric analysis of saturate fraction naphthenes.
- Gas chromatographic analysis of saturate fraction n-paraffins.
- Emission spectroscopic analysis of Vanadium/Nickel.
- Total sulfur analysis by x-ray.
- Total nitrogen analysis by Kjeldahl.

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The data for candidate tags from the M.S.-G.C. analysis were expressed as weight concentration ratios within their respective fractions i.e. $\frac{\text{Paraffin A}}{\text{Paraffin B}}$, $\frac{\text{Aromatic A}}{\text{Total aromatics}}$, and not $\frac{\text{Paraffin A}}{\text{Aromatic B}}$. Concentration ratios were used to avoid numerical changes caused by dilution or concentration of other non-tag compounds. Ratios were maintained within each fraction to avoid errors introduced in sample separation processing and arising from the use of different size samples for analysis. Vanadium/Nickel and Sulfur/Nitrogen were expressed as concentration ratios.

In the n-paraffin class of compounds, only compounds with a carbon number of 20 or greater were considered as potential tags. This was a decision, primarily based on weathering data from the Torey Canyon Spill which showed that n-paraffins below C_{18} were suceptible to weathering changes(1). All n-paraffin data used in our study were normalized to weight percents in the C_{20}-C_{40} compound range.

A preliminary analysis of replicate unweathered samples of aromatic fractions indicated that the experimental variance in specific aromatic compounds was too large (compared with differences observed from oil to oil) to be considered useful indices. However, if the summation of all, or a number of compounds of a particular empirical formula (i.e. in a particular family) were used, the measured variances were small enough (compared with differences from oil to oil) to allow them to be considered as potential tags.

Naphthene data from the high voltage mass spectrometer were available as a summation of different compounds of specific ring size and were used as such for tag evaluation.

The preliminary selection of potential oil spill identification passive tags from the large array of available data was based on the following criteria:

- Discriminating capability for the oils tested in the program.
- The precision of measuring these tags.
- Stability of tags to laboratory weathering (based on preliminary, partially complete laboratory data)*.
- Previous experience in studying real spill situations.

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* The final selection of passive tags and development of the fingerprint functions includes data from the complete factorial weathering experiment.

V/Ni and S/N were selected as preliminary candidate tags for this system. This selection was based both on previous company experience (data presented in the Esso Research Proposal for this Contract) and on data obtained during this program. Vanadium/Nickel and Sulfur/Nitrogen ratios for the oils used in this test program aided oil discrimination. This can be seen in Tables 7 and 8 which give V/Ni and S/N values for the different unweathered and a few weathered oils respectively. Table 9 shows that the analysis of these candidate tags were measured with acceptable precision.

Several polynuclear aromatic ratios were also selected as preliminary tags. This selection was based on the promising discriminatory data given in Tables 10 and 11 and Figures 12 and 13. Considering unweathered oil to oil differences, as well as the precision of measuring specific indices, the following polynuclear aromatic preliminary tags were selected:

A-1 $$\frac{\Sigma \, Cn \; H_{2n-6}}{\Sigma \, \text{Aromatics}}$$

A-2 $$\frac{\Sigma \, Cn \; H_{2n-10}}{\Sigma \, \text{Aromatics}}$$

A-3 $$\frac{\Sigma \, Cn \; H_{2n-14}}{\Sigma \, \text{Aromatics}}$$

A-4 $$\frac{\Sigma \, Cn \; H_{2n-16}}{\Sigma \, \text{Aromatics}}$$

A-5 $$\frac{\Sigma \, CnH_{2n-18}}{\Sigma \, \text{Aromatics}}$$

A-6 $$\frac{\Sigma \, Cn \; H_{2n-6} \Big|}{\Sigma \, \text{Aromatics}} \begin{matrix} C = 20 \\ C = 36 \end{matrix}$$

A-7 $$\frac{\Sigma \, Cn \; H_{2n-10} \Big|}{\Sigma \, \text{Aromatics}} \begin{matrix} C = 20 \\ C = 36 \end{matrix}$$

A-8 $$\frac{\Sigma \, CN \; H_{2n-6}}{\Sigma \, Cn \; H_{2n-18}}$$

A-9 $$\frac{\Sigma \, CnH_{2n-6} + CnH_{2n-18}}{\Sigma \, Cn \; H_{2n-14}}$$

TABLE 7

VANADIUM/NICKEL RATIO OF WEATHERED OILS

Oil	Days Weathered	Bath Temperature, °F	Mixing Conditions	V/Ni
Tia Juana Med. Crude	0	--	--	7.4
	10	55	High	7.4
	10	80	High	7.8
	21	80	High	7.6
	10	80	Low	7.8
Zuitina Crude	0	--	--	0.3
	10	55	High	0.1
	10	80	High	0.2
	21	80	High	0.3
Lago Crude	0	--	--	5.6
	10	55	High	7.2
	10	80	High	7.0
	21	80	High	5.4
	10	80	Low	6.2
Grande Isle Mix Crude	0	--	--	
	10	55	High	0.2
	10	80	High	0.2
	21	80	High	0.3
Nigerian Crude	0	--	--	0.1
	10	55	High	0.2
	21	55	High	0.1
	10	80	Low	0.3
#2 Fuel Oil	0	--	--	-10(1)
	10	55	High	-10(1)
	21	55	High	-10(1)
	10	80	High	-10(1)
	21	80	High	-10(1)
	10	80	Low	-10(1)
#4 Fuel Oil	0	--	--	5.3
	10	55	High	6.8
	21	55	Low	5.7
	21	80	Low	5.4
#5 Fuel Oil	0	--	--	8.3
	10	55	High	7.7
	10	80	High	7.9
	21	80	High	7.8
	10	80	Low	8.8

---

(1) -10 used to signify ratio of very small members, e.g., $\frac{\leq .01}{<.02}$

TABLE 8

SULFUR/NITROGEN RATIO OF WEATHERED OILS

Oil	Days Weathered	Bath Temperature, °F	Mixing Conditions	S/N
Tia Juana Med. Crude	0	--	--	6.2
	10	55	High	6.4
	21	55	High	6.1
	10	80	High	6.3
	21	80	High	5.6
	10	80	Low	6.3
Zuitina Crude	0	--	--	
	10	55	High	2.9
	10	80	High	2.2
Nigerian Crude	0	--	--	1.2
	10	55	High	1.3
	10	80	High	1.5
Lago Crude	0	--	--	6.4
	10	55	High	6.3
	21	55	High	6.6
	10	80	High	6.1
	21	80	High	6.8
	10	80	High	6.9
Grande Isle Mix Crude	0	--	--	3.9
	10	55	High	3.8
	21	80	High	4.1
	10	80	Low	3.6
#4 Fuel Oil	0	--	--	3.6
	10	55	High	3.8
	21	55	Low	3.5
	10	80	High	3.2
#5 Fuel Oil	0		--	3.9
	10	55	High	4.2
	10	80	High	4.3
	21	80	High	3.9
#2 Fuel Oil	0	--	--	11.3
	10	55	High	14.8
	10	80	High	13.5
	10	50	Low	10.0

TABLE 9

PRECISION OF NICKEL-VANADIUM SULFUR-NITROGEN MEASUREMENTS(1)

Analysis	No. of Samples	Mean Value(ppm)	Average Range	Standard Deviation	Coefficient of Variation
Nickel	11	23.3	0.6	0.53	2.3
Vanadium	11	173	6.4	5.67	3.3
Sulfur	19	1.61wt.%	0.010	0.009	0.56
Nitrogen	11	0.26	0.016	0.0124	4.8

---

(1) Tia Juana Crude (unweathered).

TABLE 10

AROMATIC COMPOUND DISTRIBUTION IN UNWEATHERED CRUDES

Aromatic Distribution
wt.% of Compound Type in Aromatic Fraction

Crude	ΣC_nH_{2n-6} Benzenes	ΣC_nH_{2n-8} Indans	ΣC_nH_{2n-10} Indenes	ΣC_nH_{2n-12} Naphthalenes	ΣC_nH_{2n-14} **Acenaphthenes**	ΣC_nH_{2n-16} Acenaphthalenes	ΣC_nH_{2n-18} Phenanthrenes
Replicate Tia Meds							
Tia Med (Replicate 1)	20.8	20.7	13.2	17.0	11.6	8.1	8.6
Tia Med (Replicate 2)	20.8	20.6	13.2	16.9	11.7	8.2	8.7
Tia Med (Replicate 3)	20.8	19.8	12.2	18.2	11.8	8.1	9.0
Tia Med (Replicate 4)	21.6	19.0	12.7	18.3	11.4	7.9	9.0
Tia Med (Replicate 5)	21.1	20.6	12.7	18.1	10.7	8.2	8.7
Tia Med (Replicate 6)	21.4	20.7	12.6	18.1	11.7	8.1	8.7
Range	0.8	1.7	1.0	1.4	1.0	0.3	0.4
Range/2	0.4	0.85	0.5	0.7	.5	0.15	0.2
Mid Range	21.2	19.9	12.7	17.6	11.2	8.1	8.8
Zuitina	16.5	19.9	14.1	18.3	12.6	9.2	9.4
Lago	18.9	20.3	13.9	16.0	12.5	8.9	9.4
Nigerian	14.9	20.7	14.6	18.4	14.2	9.5	7.7
Grande Isle Mix	18.1	20.2	13.9	19.3	11.7	8.5	8.3
No. 5 Fuel	17.9	22.8	16.1	12.7	12.7	10.1	7.7
No. 4 Fuel Oil	19.7	27.4	15.0	13.2	11.0	7.9	5.7
No. 2 Heating Oil	10.7	10.4	4.6	36.9	18.5	8.1	10.8

TABLE 11

EFFECT OF WEATHERING ON POLYNUCLEAR AROMATIC DISTRIBUTION

(55-60°F) High Mix
wt.% of Compound Type in Aromatic Fraction

Crude	Weathering Time Days	ΣC_nH_{2n-6}	ΣC_nH_{2n-8}	ΣC_nH_{2n-10}	ΣC_nH_{2n-12}	ΣC_nH_{2n-14}	ΣC_nH_{2n-16}	ΣC_nH_{2n-18}
Tia Med	0	20.8	20.7	13.2	17.0	11.6	8.1	8.6
	10	21.0	18.5	12.2	19.9	13.2	8.5	6.7
	18	24.5	22.2	14.9	16.1	12.1	6.6	3.6
	Range	3.7	3.7	2.7	3.8	1.6	1.5	5.0
Zuitina	0	16.5	19.9	14.1	18.3	12.6	9.2	9.4
	10	16.9	19.0	15.1	15.0	13.2	10.2	10.5
	21	16.9	18.8	14.7	15.3	12.8	10.5	11.1
	Range	0.4	1.1	1.0	3.3	0.6	1.3	1.7
Lago	0	18.9	20.3	13.9	16.0	12.5	8.9	9.4
	10	19.0	20.0	13.9	15.9	12.6	9.1	9.4
	21	18.7	19.9	14.0	15.8	12.6	9.3	9.7
	Range	0.3	0.4	0.1	0.2	0.1	0.4	0.3
Nigerian	0	14.9	20.7	14.6	18.4	14.2	9.5	7.7
	10	15.9	19.1	14.2	15.1	15.1	10.5	9.9
	21	14.6	19.1	14.6	17.3	15.5	10.3	8.5
	Range	1.3	1.6	0.4	3.3	1.3	1.0	2.2
Grande Isle Mix	0	18.0	20.2	13.9	19.3	11.7	8.5	8.3
	10	17.2	19.4	15.0	17.6	12.6	9.4	8.8
	21	17.5	19.6	14.1	17.6	12.5	8.6	8.8
	Range	0.8	0.8	1.1	1.7	0.9	0.9	0.5
No. 5 Fuel	0	17.9	22.8	16.1	12.7	12.7	10.1	7.7
	10	18.1	21.8	16.2	12.4	12.9	10.4	8.1
	21	18.1	21.9	16.5	12.3	13.1	10.6	7.6
	Range	0.2	1.0	0.4	0.4	0.4	0.5	0.5
No. 4 Fuel Oil	0	19.7	27.4	15.0	13.2	11.0	7.9	5.7
	10	19.0	29.8	15.7	10.7	11.9	8.7	5.8
	21	19.6	29.7	15.6	11.5	11.5	8.2	5.7
No. 2 Fuel Oil	0	10.7	10.4	4.6	36.9	18.5	8.1	10.8
	10	10.2	9.1	4.2	36.4	19.5	8.3	12.1
	21	10.5	9.4	4.3	36.6	19.1	8.3	12.7

Polynuclear Aromatic tags A-1 thru A-6 were based on their promising discriminating character. Tags A-6 and A-7 are similar to A-1 and A-2 respectively except that they include only compounds above C_{20}. Though the results of the first few (low temperature) weathering experiments indicated that there was apparently no disadvantage in including the entire molecular weight range of polynuclear compounds in ratios A-1 and A-2 (B.P > 400°F) it was felt that some differences might be seen under more severe weathering. Thus, indices A-6 and A-7 were included to test this hypothesis, using all the weathering data in the final tag selection. Tags A-8 and A-9 were included to accentuate any distribution differences in tags A-1, A-3, and A-5.

In a similar manner, the discriminating capability, precision of measurement and stability to weathering of potential naphthene compound indices were considered. The selection of specific naphthene indices was also based on data obtained from unweathered and some weathered crudes. This data is given in Tables 12 and 13. The naphthenes selected as preliminary tags included*:

N-1 $$\frac{\Sigma \text{ Paraffins}}{\Sigma \text{ Paraffins} + \text{Naphthenes}}$$

N-2 $$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma \text{Paraffin} + \text{Naphthenes}}$$

N-3 $$\frac{\Sigma \text{4 Ring Naphthenes}}{\Sigma \text{Paraffin} + \text{Naphthenes}}$$

N-4 $$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma \text{Paraffins} + \text{Naphthenes}}$$

N-5 $$\frac{\Sigma 1 + 2 \text{ Ring Naphthenes}}{\Sigma 5 + 6 \text{ Ring Naphthenes}}$$

Tags N-3 and N-4 showed the best combined preliminary discriminating capability and precision of measurement of the naphthene groups. Tags N-1, and N-2 were less discriminating but showed sufficient potential to be included. Selection of index N-5 as a preliminary tag could not be completely justified on the basis of the preliminary data at hand. However, it was included to determine whether an effective tag would result by accentuating the general naphthene distribution seen in all samples - i.e. richer in low number ring compounds - leaner in higher number ring compounds.

The preliminary selection of n-paraffin candidate tags were based on comparative G.C. analysis of unweathered and a few weathered samples. Data used in the n-paraffin selection are presented in Tables 14 and 15 and Figures 4 and 5. As indicated earlier, only n-paraffin compounds with a carbon number of 20 or greater were considered. Results

---

* All naphthene and aromatic tags contain no compounds with a boiling point < 400°F.

TABLE 12

NAPHTHENE DISTRIBUTION IN UNWEATHERED CRUDES

wt.% of Compound Type in Paraffin + Naphthene Fraction

Crude	wt.% Parafins in P+N Fraction	Σ1-Ring Naphthenes	Σ2-Ring Naphthenes	Σ3-Ring Naphthenes	Σ4-Ring Naphthenes	Σ5-Ring Naphthenes	Σ6-Ring Naphthenes
Replicate Tia Meds							
Tia Med	3.42	22.8	18.1	11.2	7.4	3.6	2.3
Tia Med	34.9	22.9	18.5	11.2	6.9	3.3	1.9
Tia Med	31.2	25.7	19.7	11.9	6.8	2.9	1.7
Tia Med	32.3	25.8	20.2	11.3	6.1	2.5	1.2
Tia Med	32.2	25.6	19.9	11.1	6.2	2.9	1.7
Tia Med	39.5	20.1	17.0	10.5	6.9	3.4	2.2
Range	8.3	5.7	3.2	1.4	1.3	1.1	1.1
Range/2	4.2	2.8	1.6	.7	.7	.6	.6
Mid Range	35.4	23.9	18.6	11.2	6.8	3.1	1.8
Zuitina(R)	46.2	20.6	14.0	8.2	5.7	2.9	2.0
Zuitina(R')	46.5	21.1	14.2	8.2	5.6	2.6	1.5
Mid Range	46.4	21.4	14.1	8.2	5.6	2.8	1.8
Lago	16.6	25.4	24.0	16.6	10.5	4.5	2.3
Nigerian	40.7	15.7	16.3	13.1	8.3	3.5	2.0
Grande Isle Mix	29.9	22.7	17.9	12.3	9.7	4.5	2.3
No. 4 Fuel Oil	34.9	26.4	20.4	11.2	5.5	1.5	0.16
No. 5 Fuel Oil	28.4	25.5	20.2	12.9	6.8	3.6	2.1
No. 2 Fuel Oil	51.2	17.4	14.7	9.4	5.2	2.0	0

TABLE 13

EFFECT OF WEATHERING ON NAPHTHENE DISTRIBUTION

(55-60°F) High Mix
Wt. % of Compound Type

Crude	Days Weathered	% P / P+N	Σ1 Ring Naphthenes	Σ2 Ring Naphthenes	Σ3 Ring Naphthenes	Σ4 Ring Naphthenes	Σ5 Ring Naphthenes	Σ6 Ring Naphthenes
Tia Med	0	35.4	23.9	18.6	11.2	6.8	3.1	1.8
	10	36.2	22.5	19.2	11.7	6.6	2.5	1.2
	21	36.2	22.2	19.0	11.8	6.8	2.6	1.3
Zuitina	0	46.4	21.4	14.1	8.2	5.6	2.8	1.8
	10	46.5	20.4	14.2	8.5	6.4	2.5	1.2
	21	47.1	20.4	14.2	8.4	6.2	2.4	1.0
Lago	0	16.6	25.4	24.0	16.6	10.5	4.5	2.3
	10	23.8	22.5	23.1	16.5	9.2	3.6	1.3
	21	22.2	23.0	23.1	16.1	10.0	3.9	1.7
Nigerian	0	40.7	15.7	16.3	13.1	8.3	3.5	2.0
	10	39.8	15.9	14.2	13.9	10.1	4.3	1.8
	21	40.7	17.8	14.2	12.9	8.9	3.6	1.7
Grande Isle Mix	0	29.9	22.7	17.9	12.3	9.7	4.5	2.3
	10	31.9	23.2	18.6	12.1	9.0	3.4	0.9
	21	30.0	22.9	18.0	12.2	9.5	4.0	1.0
No. 5 Fuel Oil	0	28.4	25.5	20.2	12.9	6.8	3.9	2.1
	10	33.5	22.5	10.8	12.1	7.9	3.4	1.6
	21	31.2	23.4	19.1	12.6	8.4	3.6	1.8
No. 4 Fuel Oil	0	34.9	26.4	20.4	11.2	5.5	1.5	0.16
	10	35.1	26.2	19.9	11.5	5.7	1.5	0.00
	21	35.0	26.2	19.9	11.2	5.5	1.5	0.00

TABLE 14

PRECISION OF n-PARAFFINS USING GAS CHROMATOGRAPHY

Weight % in C_{20} - C_{40}

Crude	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}
Replicate Tia Juana Meds											
A	14.8	11.7	10.2	8.7	7.9	8.4	6.5	6.1	4.3	3.8	3.2
C-1	14.4	11.7	9.8	8.5	8.0	7.7	6.1	5.9	5.1	3.7	3.2
D-2	15.0	11.9	10.4	8.8	8.8	8.4	6.4	5.7	4.9	4.0	3.4
S	14.6	11.5	10.4	8.6	8.0	8.4	6.1	5.7	5.0	4.0	3.6
U	14.3	11.1	10.2	8.9	8.2	8.1	6.6	5.9	4.8	3.9	3.2
Av.	14.6	11.6	10.2	8.7	8.2	8.2	6.4	5.9	4.8	3.9	3.3
Range	0.7	0.8	0.6	0.4	0.9	0.7	0.5	0.4	0.8	0.3	0.4
Mid Range	14.7	11.5	10.1	8.7	8.4	8.1	6.4	5.9	4.7	3.9	3.4
Lago Q	11.3	8.8	8.8	8.3	7.5	8.9	6.2	6.9	4.8	3.9	2.9
Grande Isle Mix	19.2	13.2	10.0	7.3	7.4	7.7	5.5	4.7	3.3	2.8	2.8
Zuitina (R)	13.7	11.7	10.4	9.0	8.1	7.3	6.1	5.4	4.7	4.3	3.7
No. 2 Fuel Oil	47.0	28.2	13.8	6.4	2.4	1.0	0.5	0.3	0.3	0.2	0
No. 4 Fuel Oil	19.3	12.0	8.9	8.1	7.0	7.0	6.5	5.7	4.5	3.7	3.4
No. 5 Fuel Oil	12.0	10.5	9.6	8.8	8.4	9.9	7.2	7.1	5.7	4.5	3.7

TABLE 15

n-PARAFFINS IN WEATHERED CRUDES USING GAS CHROMATOGRAPHY (55°F HIGH MIX)

Weight % in C_{20} - C_{40}

Crude	Weathering Time (Days)	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}
Tia Medium	0	14.6	11.6	10.2	8.7	8.2	8.2	6.4	5.9	4.8	3.9	3.3
	10	14.9	11.9	10.6	9.0	8.2	8.2	6.0	5.8	4.7	3.8	3.2
	21	15.9	13.2	11.2	9.5	8.6	8.4	5.9	5.9	4.5	3.9	3.1
	Range	1.3	1.6	1.0	0.8	0.4	0.2	0.5	0	0.3	0	0.2
Lago	0	11.3	8.8	8.8	8.3	7.5	8.9	6.2	6.9	4.8	3.9	2.9
	10	12.5	10.5	9.3	8.2	7.3	8.7	5.5	6.2	4.0	3.0	2.2
	21	11.7	9.0	8.9	8.2	7.3	8.8	5.6	6.7	4.4	3.5	2.7
	Range	1.2	1.7	0.5	0.1	0.2	0.2	0.7	0.7	0.8	0.9	0.7
Zuitina	0	13.7	11.7	10.4	9.0	8.1	7.3	6.1	5.4	4.7	4.3	3.7
	10	14.5	12.1	10.7	9.8	8.8	7.1	6.5	5.8	4.6	4.1	3.4
	21	13.3	11.8	10.5	9.4	8.6	8.2	6.5	5.7	4.8	4.3	3.7
	Range	1.2	0.4	0.3	0.8	0.5	0.9	0.4	0.4	0.2	0.2	0.3
Grande Isle Mix	0	19.2	13.2	10.0	7.3	7.4	7.7	5.5	4.7	3.3	2.8	2.8
	10	19.7	13.3	10.7	8.3	7.8	8.8	6.0	4.6	2.7	2.7	2.3
	21	19.5	13.2	10.6	7.7	7.6	7.9	5.7	4.6	2.8	2.7	2.5
	Range	0.8	0.1	0.7	1.0	0.4	1.1	0.5	0.1	0.5	0.1	0.5
No. 2 Fuel Oil	0	47.0	28.2	13.8	6.4	2.4	1.0	0.5	0.3	0.2	0	
	10	46.6	28.2	13.9	6.1	2.6	1.1	0.5	0.3	0.2	0.1	
	21	48.5	27.2	15.2	5.7	2.3	0.8	0.2	0.1	0	0	
	Range	1.5	1.0	1.4	0.7	0.3	0.3	0.3	0.2	0.2	0.1	
No. 4 Fuel Oil	0	19.3	12.0	8.9	8.1	7.0	7.0	6.5	5.7	4.5	3.7	3.4
	10	17.4	11.4	7.9	7.1	6.6	7.1	6.6	6.1	4.2	4.2	3.7
	21	17.6	11.4	8.0	7.2	6.7	7.1	6.5	6.1	4.3	4.2	3.5
	Range	1.7	0.6	1.0	1.0	0.4	0.1	0.1	0.4	0.2	0.5	0.3
No. 5 Fuel Oil	0	12.0	10.5	9.6	8.8	8.4	9.9	7.2	7.1	5.7	4.5	3.7
	10	11.2	10.0	9.7	8.7	8.4	9.1	7.5	7.2	5.3	4.4	3.9
	21	10.9	10.2	9.2	8.3	7.8	8.3	6.8	7.1	5.7	4.8	3.9
	Range	1.1	0.5	0.5	0.5	0.6	0.8	0.7	0.1	0.4	0.3	0.2

of previous studies from real spill situations precluded inclusion of lower molecular weight n-paraffins(1). N-paraffin indices selected for further evaluation in the final selection of tags included.

P-1
$$\frac{C_{20}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-2
$$\frac{C_{21}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-3
$$\frac{C_{24}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-4
$$\frac{C_{25}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-5
$$\frac{C_{26}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-6
$$\frac{C_{27}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-7
$$\frac{C_{30}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-8
$$\frac{C_{31}}{\Sigma\text{n-Paraffins}} \quad \begin{matrix}C=20\\ C=40\end{matrix}$$

P-9
$$\frac{\Sigma C_{20} + C_{21} + C_{22}}{C_{30} + C_{31} + C_{32}}$$

P-10
$$\frac{\Sigma C_{20} + C_{21} + C_{22} + C_{30} + C_{31} + C_{32}}{\Sigma C_{24} + C_{25} + C_{26} + C_{27}}$$

Indices P-1 - P-8 were selected primarily because they appeared to discriminate fairly well among the unweathered test oils. Indices P-9 and P-10 contain several n-paraffin compounds in the numerator and were included to determine if such tags had less variance (from experimental error in G.C. measurement) and were better discriminators.

Thus, a total of 26 indices were selected for further evaluation with the complete set of weathering test data. These are summarized in Table 16. A complete tabulation of these 26 indices for the weathered and unweathered samples used in this study is presented in Appendix D. This data provided the basis for developing the final fingerprint function for the 8 different oils used in the study. The techniques used to obtain these fingerprint functions are described in the following sections.

TABLE 16

Data Format Listing

PRELIMINARY FINGERPRINT INDICES

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	
I_2	$\frac{S}{N}$	
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}_{c=36}^{c=20}$	
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}_{c=36}^{c=20}$	
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	
I_{10}	$\frac{\Sigma \text{ Paraffins}}{\Sigma (P+N)}$	
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma (P+N)}$	
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma (P+N)}$	
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma (P+N)}$	
I_{14}	$\frac{C20}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{15}	$\frac{C21}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{16}	$\frac{C24}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{17}	$\frac{C25}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{18}	$\frac{C26}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	

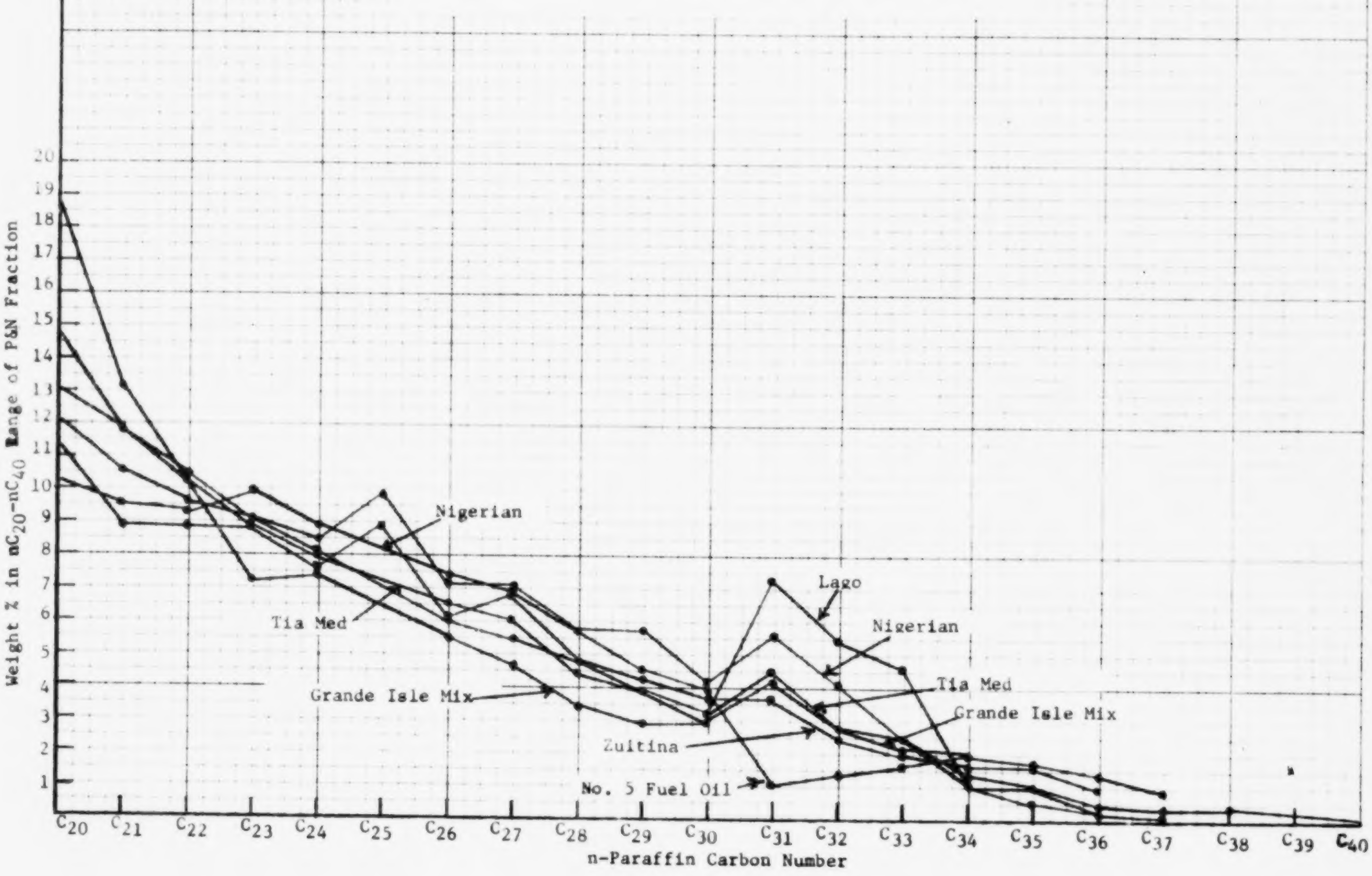
Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{20}	$\frac{C30}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{21}	$\frac{C31}{\Sigma n Paraffin}{}_{c=40}^{c=20}$	
I_{22}	$\frac{\Sigma n\, C20+C21+C22}{\Sigma n\, C_{30}+C_{31}+C_{32}}$	
I_{23}	$\frac{\Sigma n\, C20+C21+C22+C30+C31+C32}{\Sigma n\, C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	

Sample History

Oil Type -
Origin -
Weathering Time, days -
Weathering Temperature, °F -
Mixing Condition -

FIGURE 4

n-PARAFFIN DISTRIBUTION OF UNWEATHERED SAMPLES



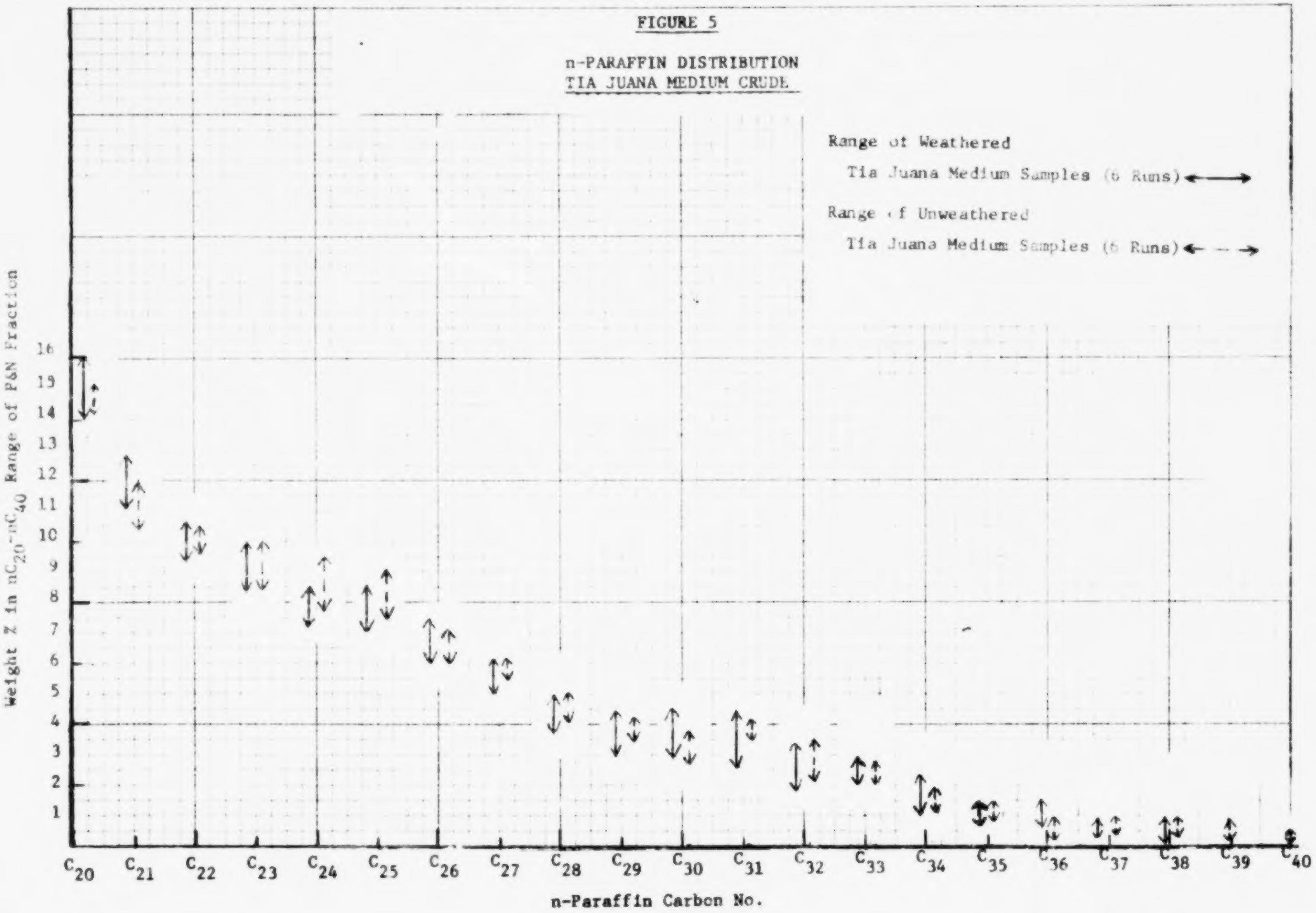


FIGURE 5

n-PARAFFIN DISTRIBUTION
TIA JUANA MEDIUM CRUDE

FIGURE 6

n-PARAFFIN DISTRIBUTION
LAGO CRUDE OIL

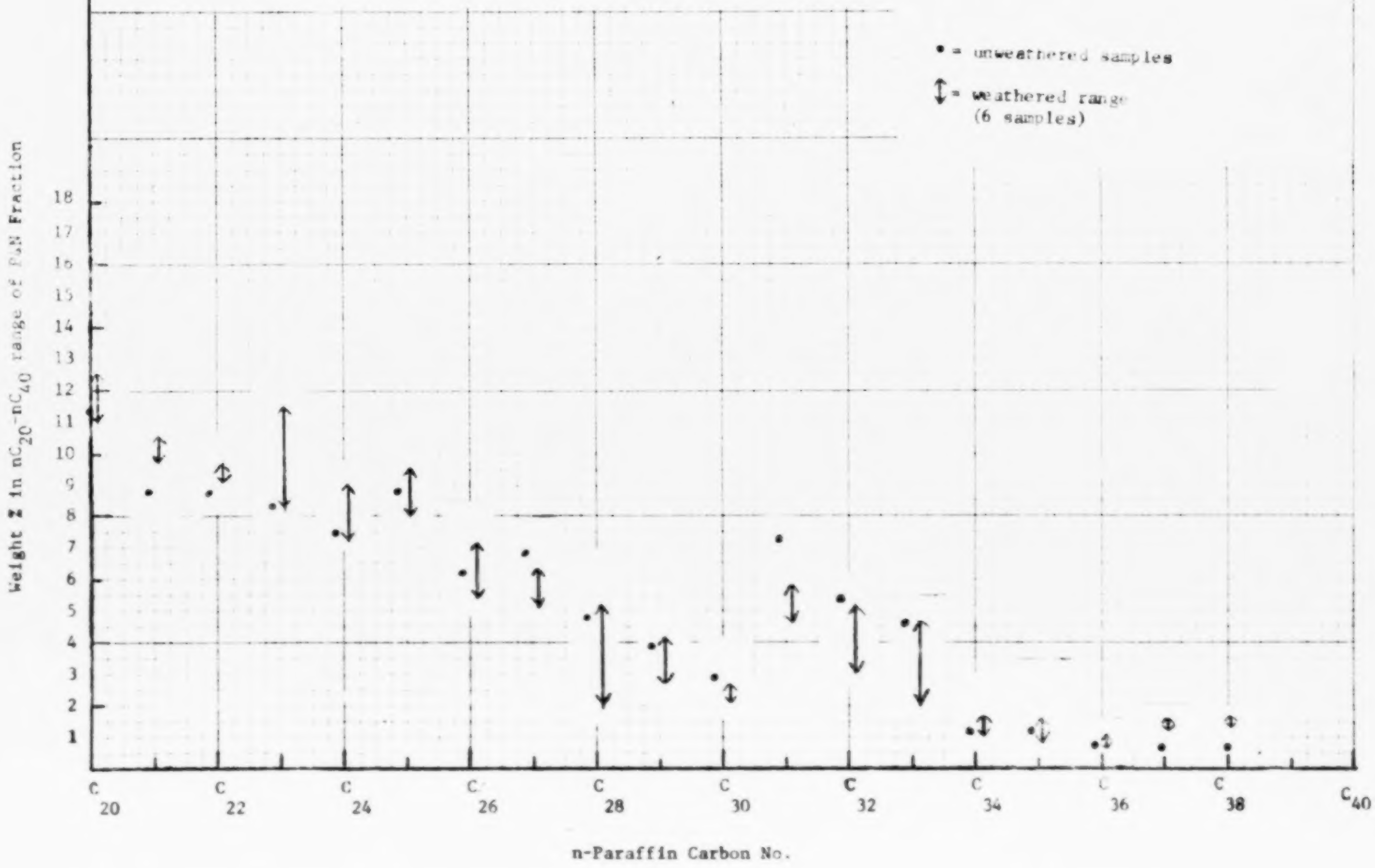


FIGURE 7

n-PARAFFIN DISTRIBUTION
GRAND ISLE MIX CRUDE OIL

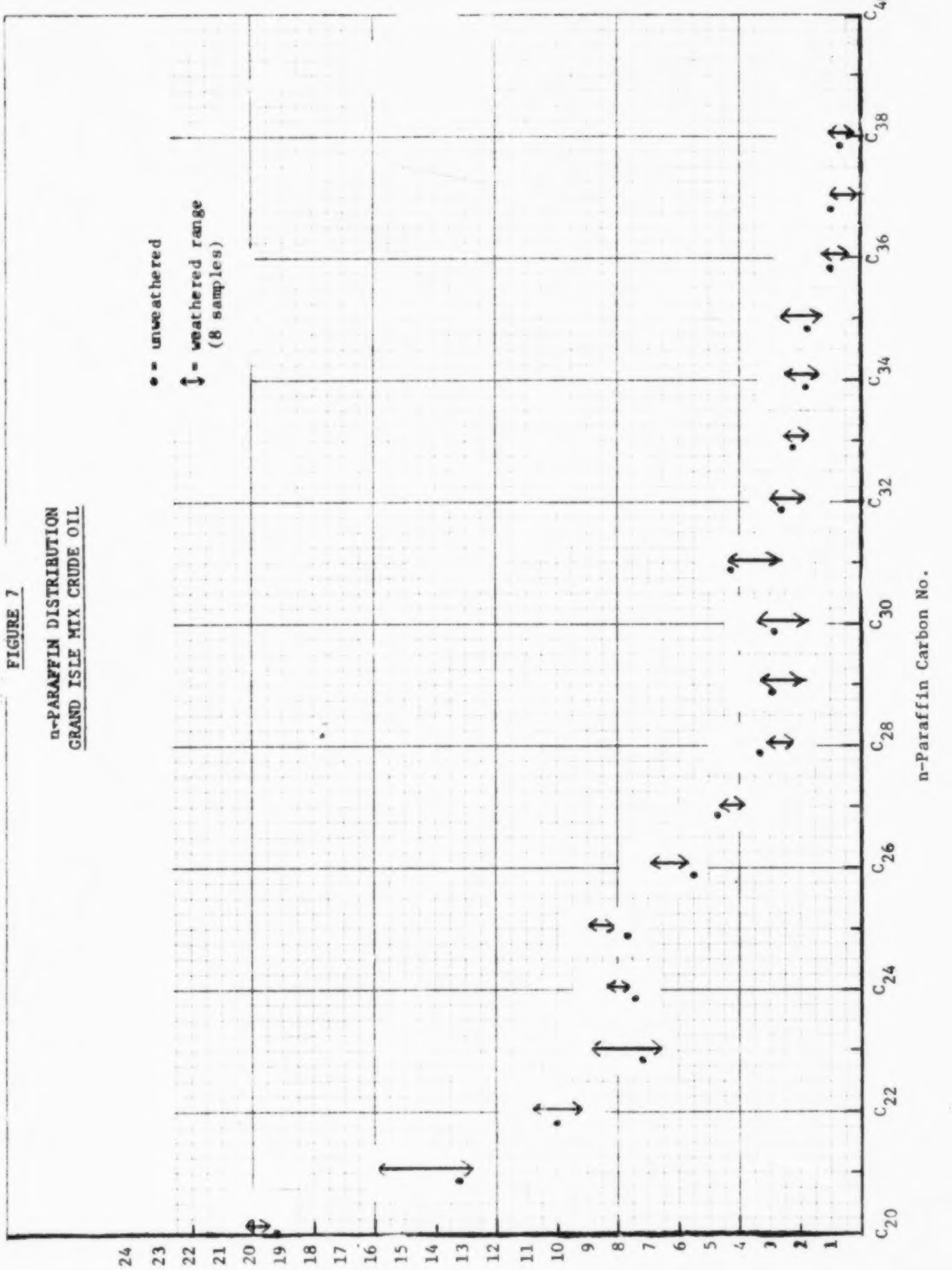


FIGURE 8

n-PARAFFIN DISTRIBUTION
NIGERIAN CRUDE OIL

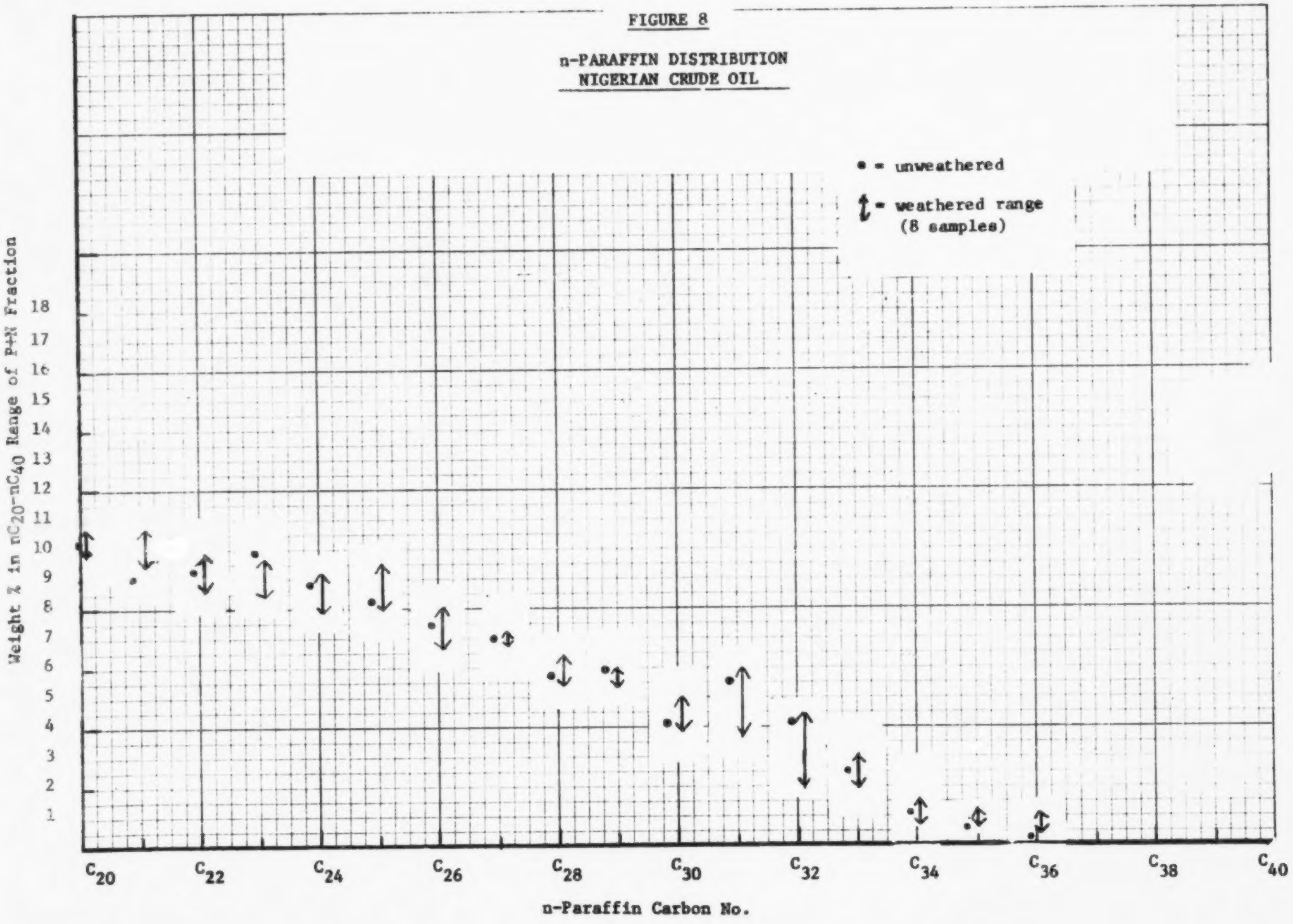
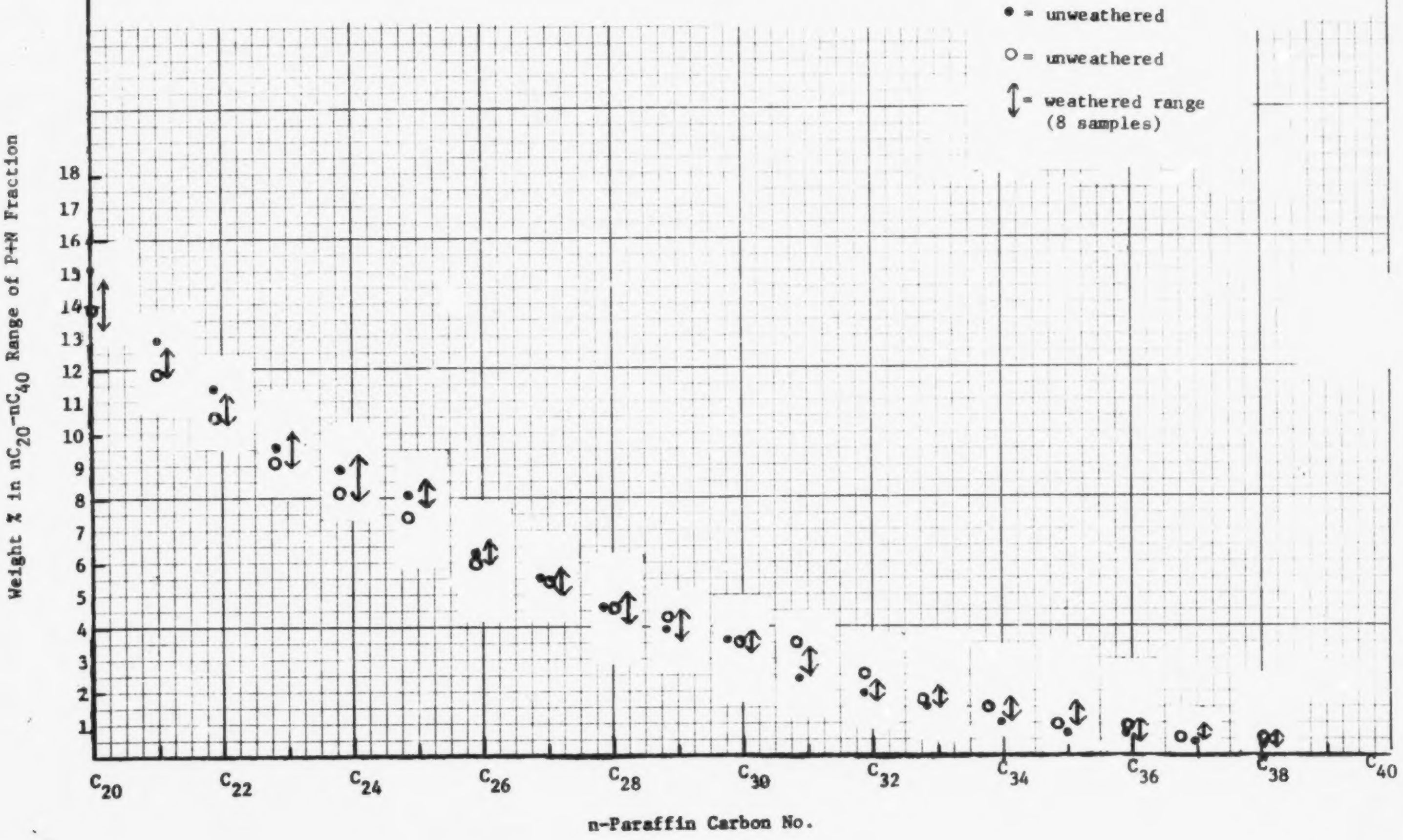


FIGURE 9

n-PARAFFIN DISTRIBUTION
ZUITINA CRUDE OIL



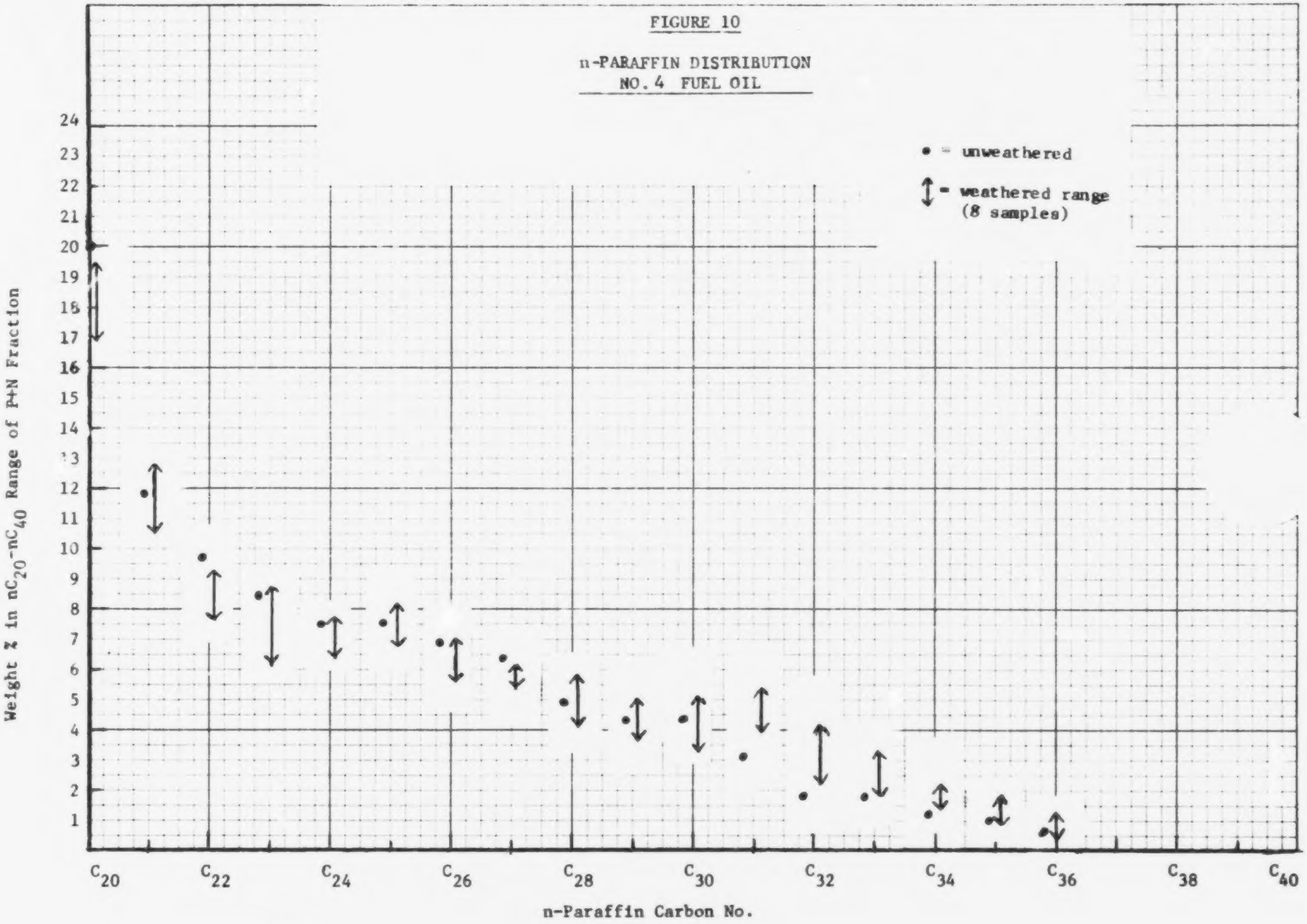


FIGURE 10

n-PARAFFIN DISTRIBUTION
NO. 4 FUEL OIL

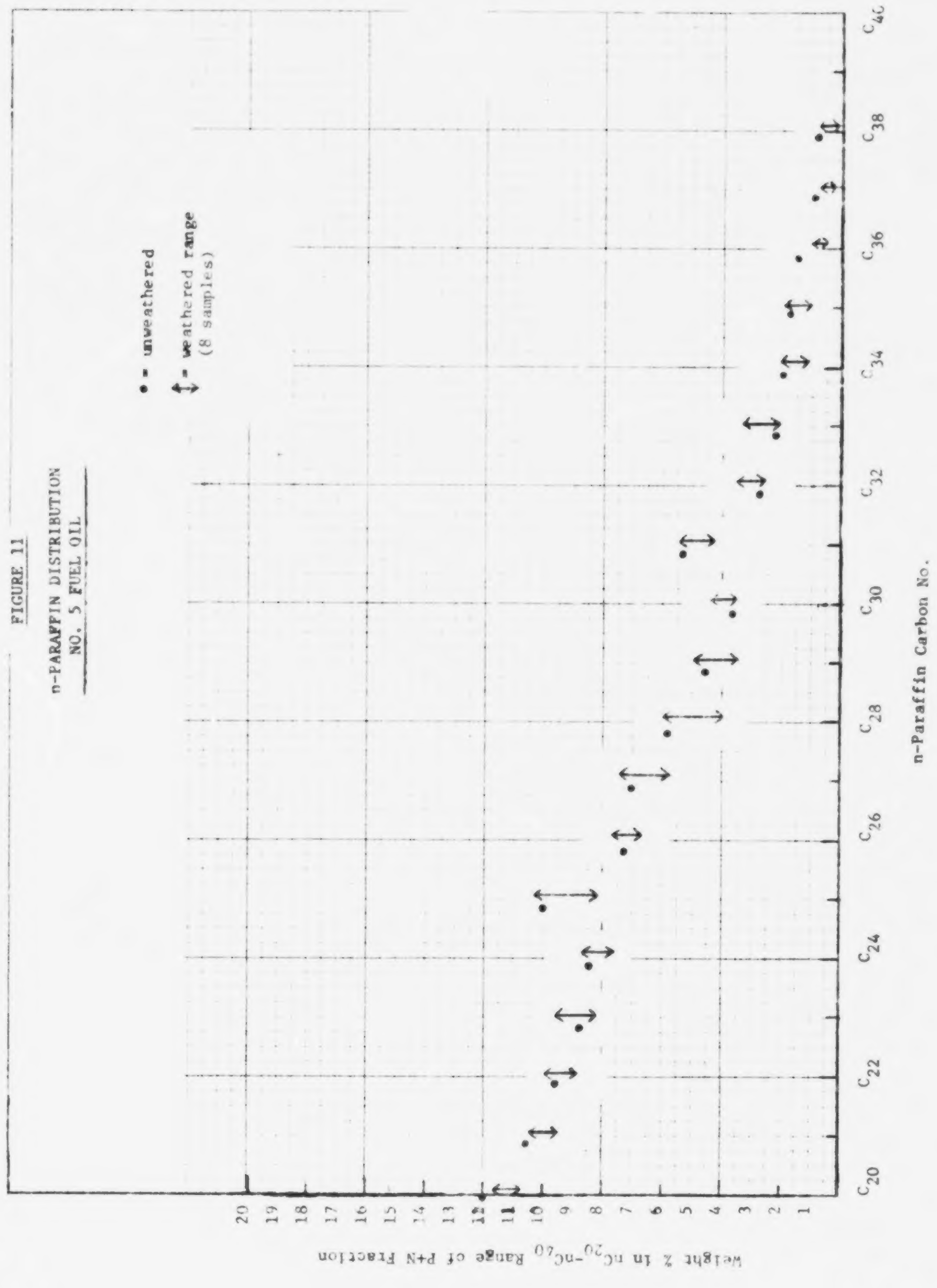


FIGURE 11

n-PARAFFIN DISTRIBUTION
NO. 5 FUEL OIL

FIGURE 12

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
TIA JUANA MEDIUM CRUDE

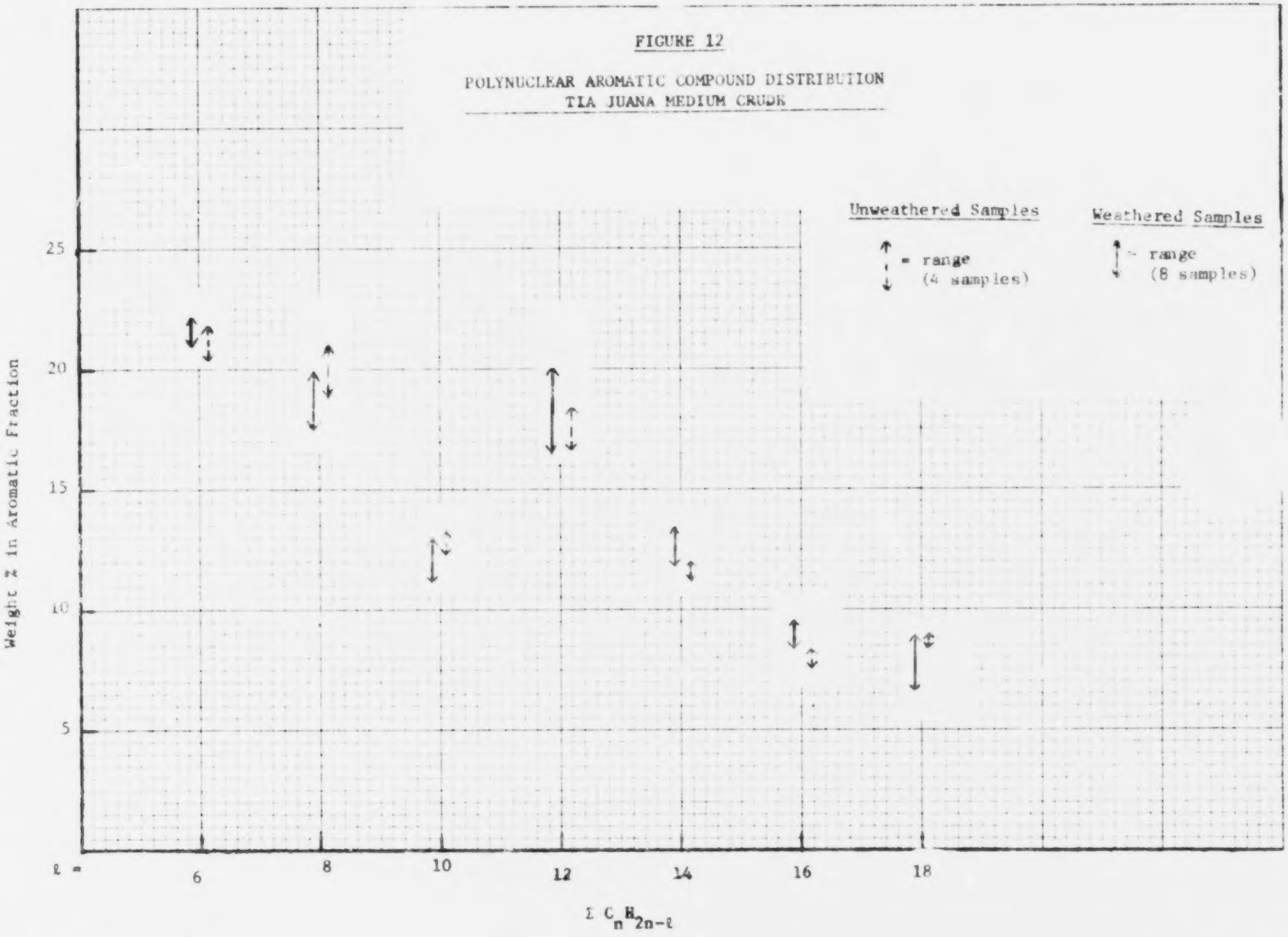
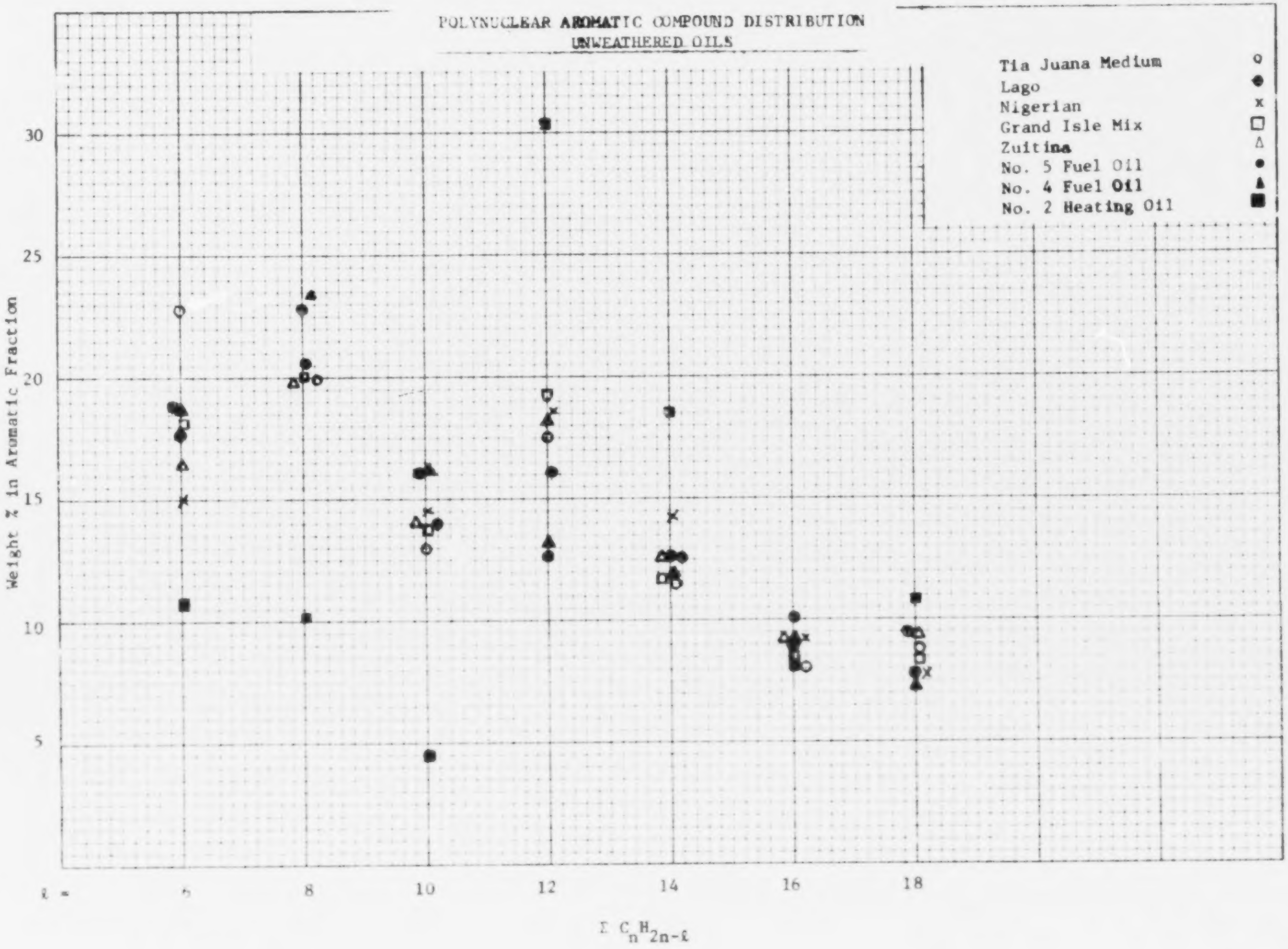


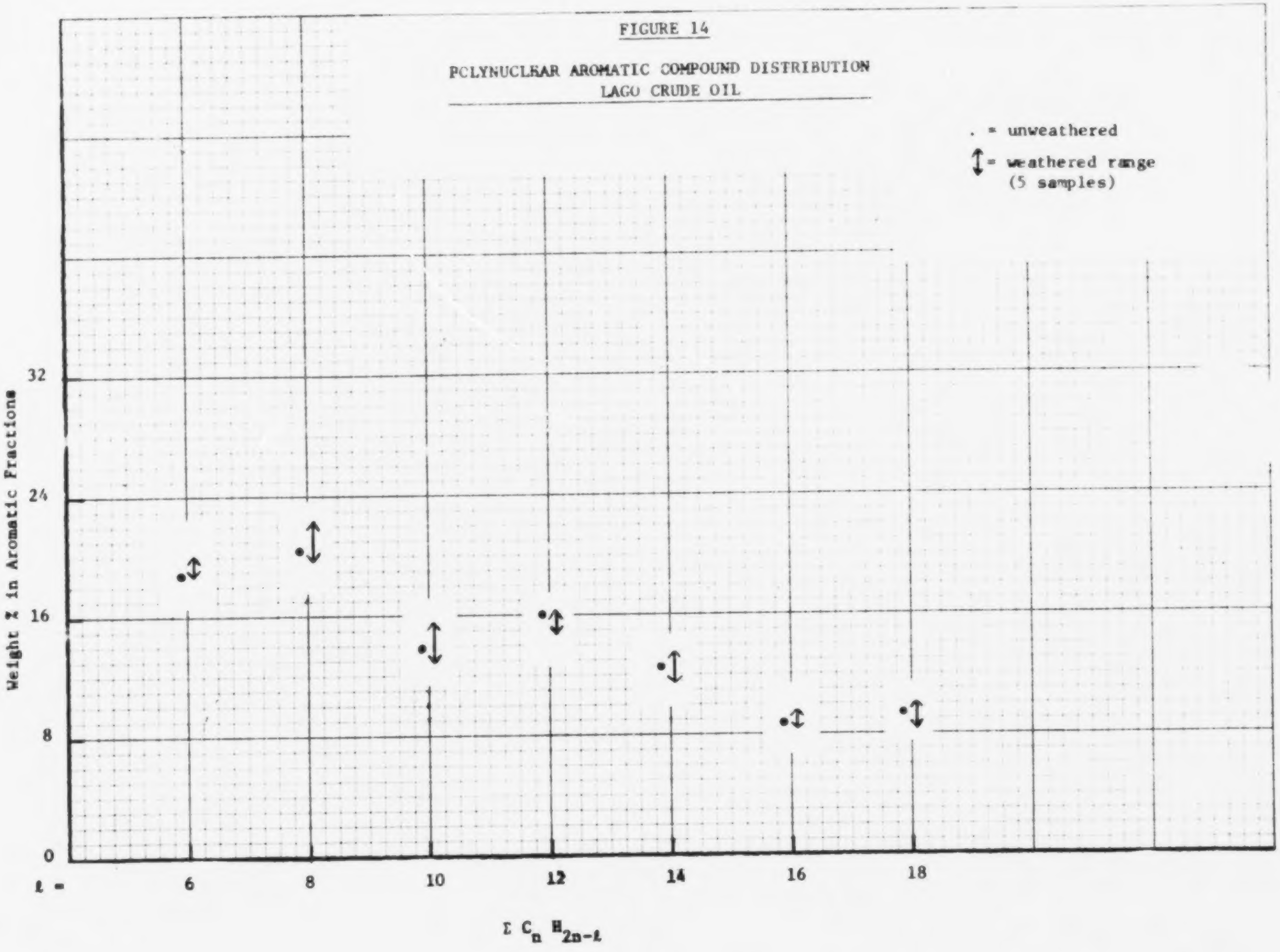
FIGURE 13



POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
UNWEATHERED OILS

FIGURE 14

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
LAGO CRUDE OIL



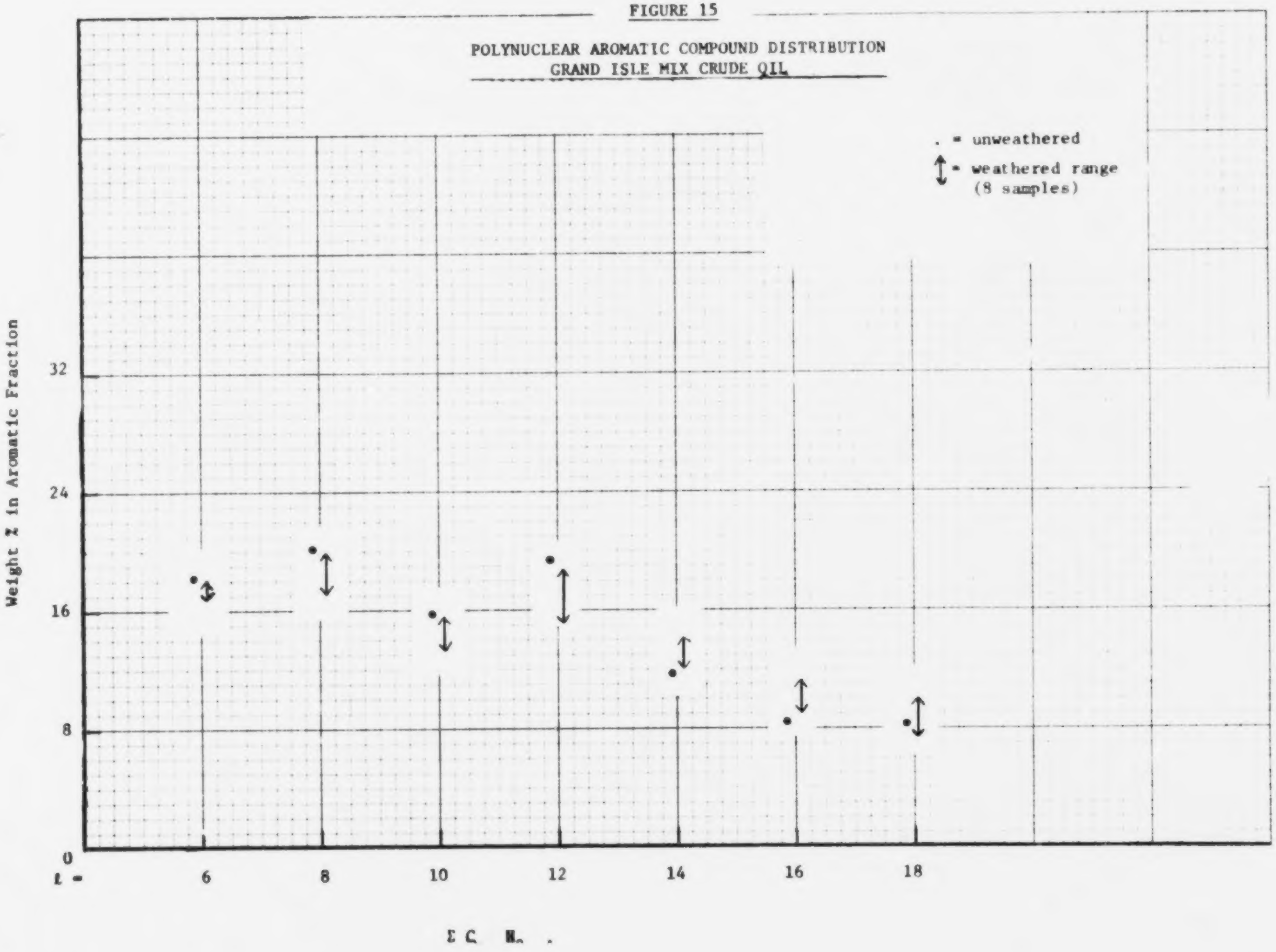


FIGURE 15

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
GRAND ISLE MIX CRUDE OIL

FIGURE 16

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
NIGERIAN CRUDE OIL

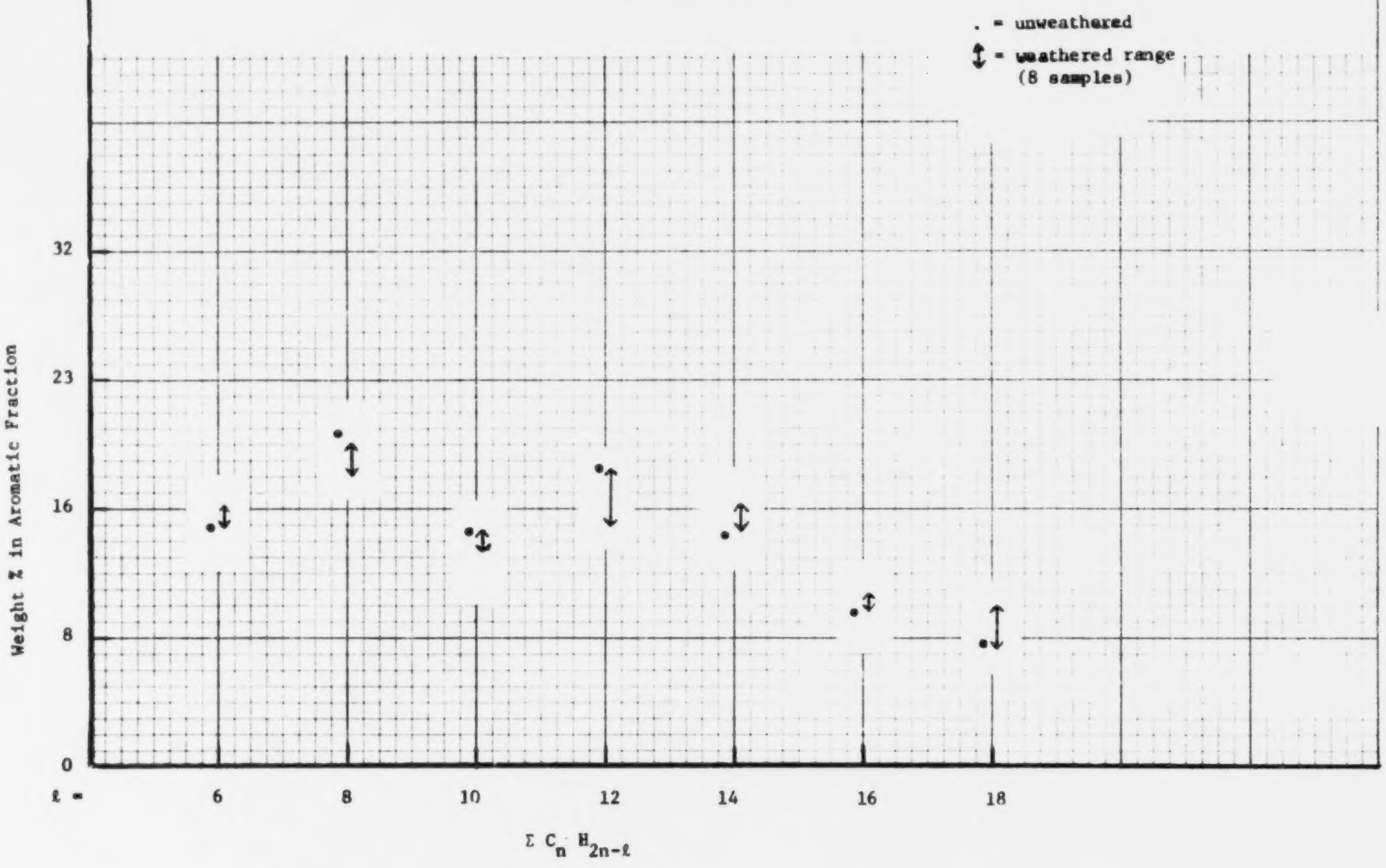


FIGURE 17

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
ZUITINA CRUDE OIL

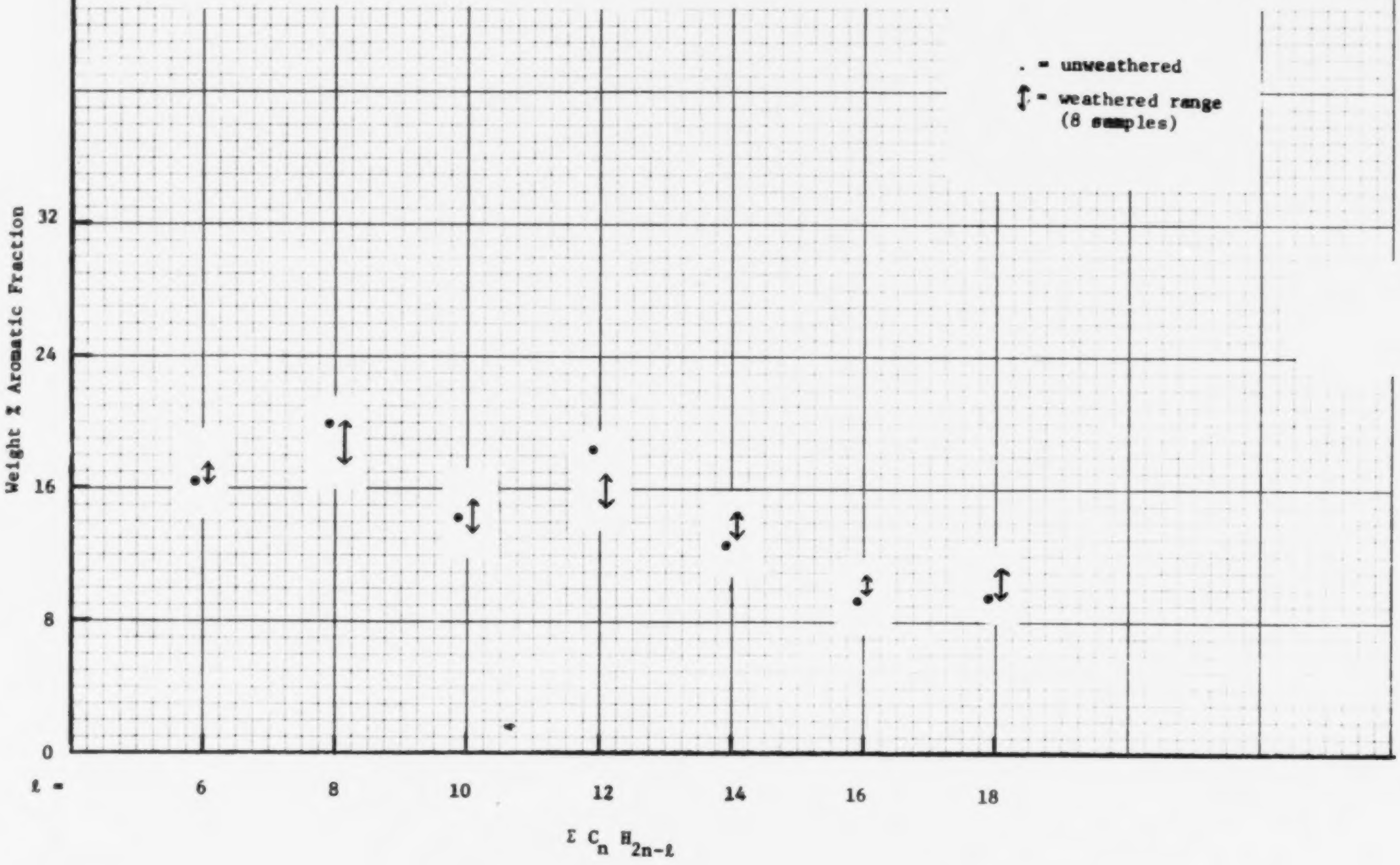


FIGURE 18

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
NO. 2 FUEL OIL

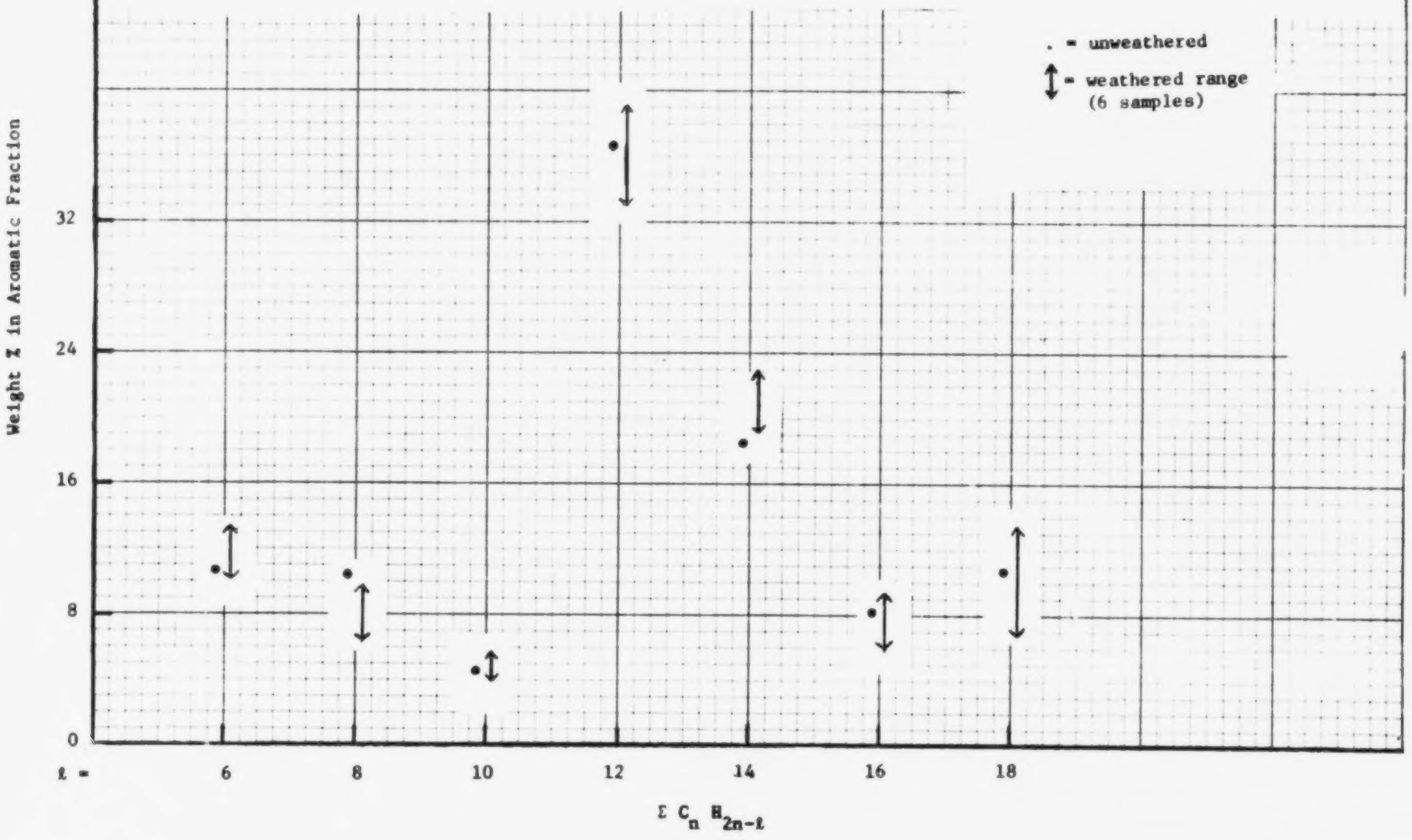


FIGURE 19

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION NO. 4 FUEL OIL

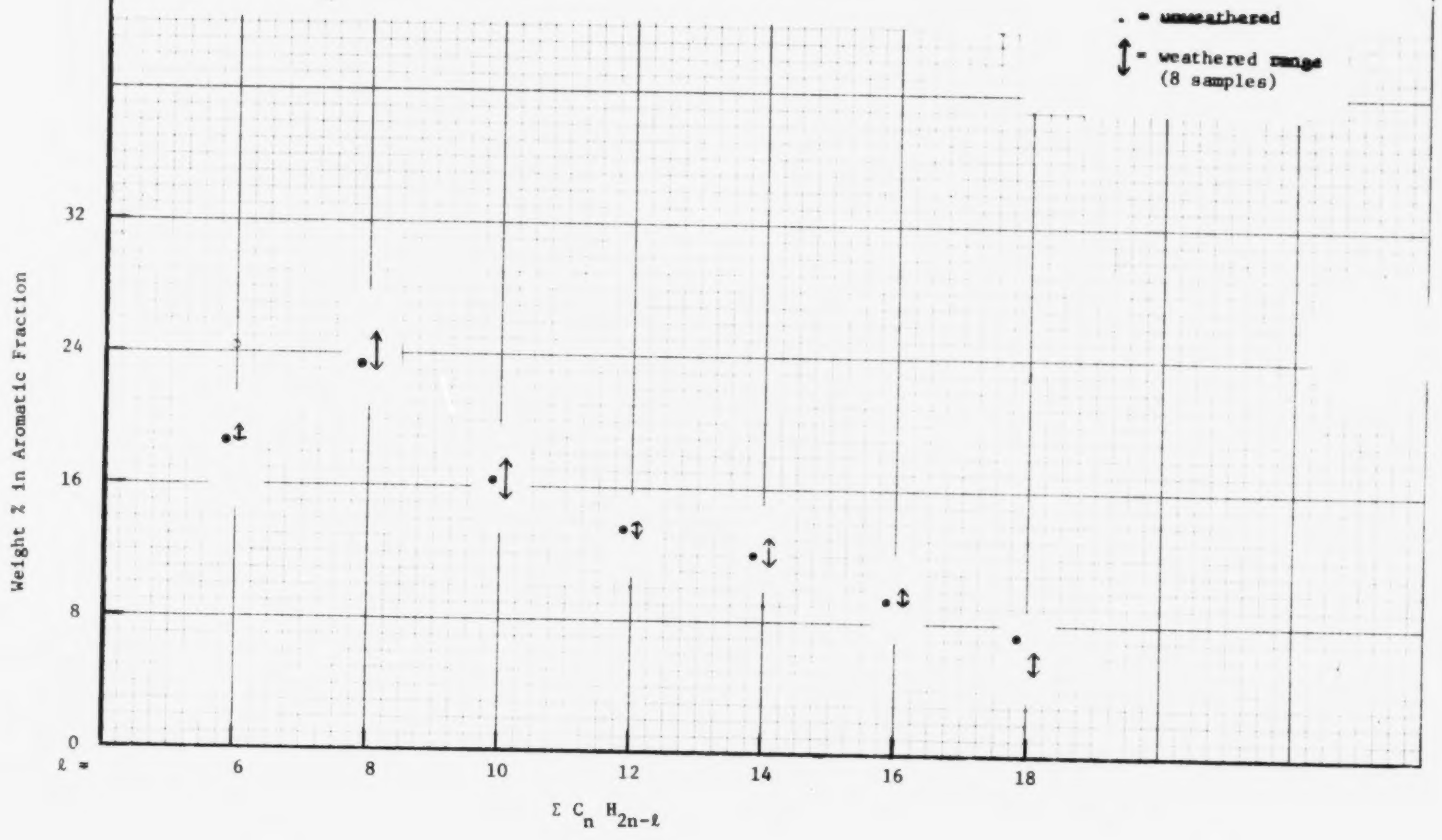
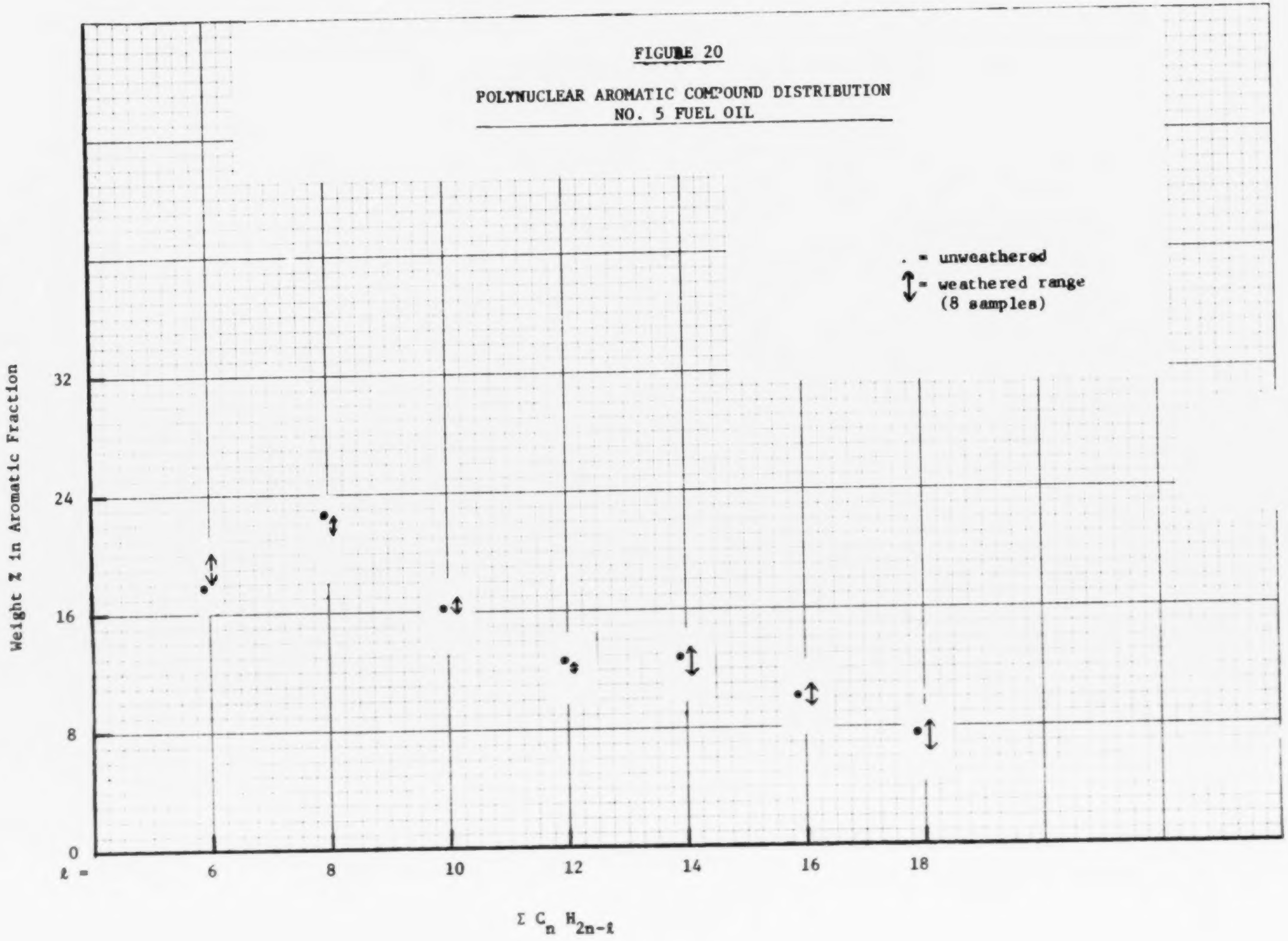


FIGURE 20

POLYNUCLEAR AROMATIC COMPOUND DISTRIBUTION
NO. 5 FUEL OIL



7.2 Development of the Final Fingerprint Indices Using Discriminant Function Analysis

The twenty-six preliminary indices selected in Section 7.1 were then subjected to Discriminant Function Analysis to select the best discriminators for the test oils used in this program. Discriminant function analysis is a multivariate technique for differentiating between two groups of populations. It is employed to estimate a function which will combine the variables of interest (compound indices) in such a way as to produce a function which provides the best discrimination between the two populations. For example, for two crudes, one may write

$$\text{Crude 1} \qquad Y_1 = a_1 \bar{X}_{11} + a_2\bar{X}_{2,} + \ldots\ldots\ a_n\bar{X}_{n1} \qquad (1)$$

$$\text{Crude 2} \qquad Y_2 = a_1 \bar{X}_{12} + a_2\bar{X}_{22} + \ldots\ldots\ a_n\bar{X}_{n2} \qquad (2)$$

$$D = Y_1 - Y_2$$

where X_{ij} = characteristics (preliminary fingerprint indices).

i = particular measurement (specific test run).

j = group (Crude or Fuel Oil).

a = Coefficients which give proper weight to the final compound indices in the final discriminant function.

D = the discriminant function.

The discriminant function attempts to find the value of the coefficient that will give the maximum relative difference between the two overall responses Y_1 and Y_2, i.e., the highest resolution between two oils. In the process of determining the discriminant function, the analysis technique selects the best characteristics (compound indices) which maximize the difference in the two populations, while discarding those characteristics (compound indices) that reduce the resolution of the function.

In the use of the discriminant function technique to distinguish among the oils used in this program, runs conducted at different weathering conditions (as well as unweathered oils) were used to represent the population (replicates) of a specific oil. The fact that the laboratory simulated weathering did not notably affect the preliminary selected indices justified their use as replicates (1). Each test oil in the program was used as a separate group in the analysis.

---

(1) The effects of laboratory simulated weathering on the final compound indices selected in the discriminant function were minimal. Weathering data on all test oils (Tia Med. Crude, No. 2 oil and No. 5 oil) are summarized in Appendix C.

The general approach used to develop the discriminant function in this program is summarized as follows:

- Selection of the most definitive compound indices (from array of preliminary indices) by the application of a step-wise multiple regression technique. This is a statistical analysis, which, on the basis of a variable contributing to the goodness of the fit, elects the significant variables (compound indices) from those considered and then fits them to the data by the method of least squares.

- Calculation of the discriminant function to discriminate between two groups (test oils). This involves solving a set of simultaneous equations corresponding to the two groups of oil samples being compared. For groups 1 and 2 (equations 1 and 2) the following simultaneous equations must be solved:

$$\alpha^2\Delta_1 = a_1\ \Sigma X_1^{\ 2} + a_2\Sigma X_1X_2 + a_3\ \Sigma X_1X_3 + \ldots .\ a_n\ \Sigma X_1X_n \qquad (3)$$

$$\alpha^2\Delta_2 = a_1\ \Sigma X_1X_2 + a_2\ \Sigma X_2^2 + a_3\Sigma X_2X_3 + \ \ldots .\ a_n\ \Sigma X_2X_n \qquad (4)$$

$$\alpha^2\Delta_n = a_1\ \Sigma X_1X_n + a_2\ \Sigma X_2X_n + a_3\Sigma X_3Xn + \ \ldots\ a_n\ \Sigma Xn^2 \qquad (5)$$

where $\alpha^2 = \dfrac{n_1n_2}{n_1n_2}$

n_1 = number of replicates of oil 1.

n_2 = number of replicates of oil 2.

$\Delta i = \bar{X}i_1 - \bar{X}i_2$ (6)

a_i = unknown weighted coefficients for each variable X_i.

The above equations are solved for the condition

$$\bar{y} = \frac{\Sigma y}{n_i + n_2} = \frac{\dfrac{n_1n_2}{n_1 + n_2} - \dfrac{n_1n_2}{n_1 + n_2}}{n_1 + n_2} = 0 \qquad (7)$$

After applying the discriminant function analysis to the oils studied in the program, the following five variable (index) general function was obtained for the best discrimination.

$$D = a_i \left[\frac{V}{Ni} \right] + a_2 \left[\frac{\Sigma \text{Paraffins}}{\Sigma P{+}N} \right] + a_3 \left[\frac{\Sigma 5 \text{ Ring Naphthenes}}{\Sigma P{+}N} \right]$$

$$+ a_4 \left[\frac{C_{20}}{\Sigma \text{Paraffins}} \Bigg|_{40}^{20} \right] + a_5 \left[\frac{\Sigma 1 + 2 \text{ Ring Naphthenes}}{\Sigma 5 + 6 \text{ Ring Naphthenes}} \right] \qquad (8)$$

Equation (8) describes a function which gives the best overall discrimination between all pairs of oils used in the study. It provides a means of enhancing the differences in fingerprint indices that exist. The coefficients used in equation (8) were obtained in the analysis and depend on which two oils are considered at a time. They are summarized in Table 17.

7.3 Estimation of the Probability of Oil Misclassification Using the Discriminant Function

The probability of misclassification in any combination of pairs of test oils used in the program was determined using the discriminant function data and the following relationships (6):

$$P_m = \phi\left(\frac{0.5}{s_D}\right) \qquad (9)$$

and

$$s_D = \sqrt{\frac{\lambda^2 \; R^2 \; (1 - R^2)}{n_1 + n_2 - p - 1}} \qquad (10)$$

where P_m = probability of misclassification

ϕ = normalized probability function

s_D = the standard deviation as defined above

$\lambda^2 = \dfrac{n_1 \, n_2}{n_1 + n_2}$

TABLE 17

SUMMARY OF COEFFICIENTS FOR DISCRIMINANT FUNCTION

	a_1	a_2	a_3	a_4	a_5		
Oil Comparisons	$\frac{V}{Ni}$	$\frac{\Sigma P}{\Sigma P + N}$	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma P + N}$	$\frac{C_{20}}{\Sigma\ \text{Paraffin}}\Big\}\begin{matrix}20\\40\end{matrix}$	$\frac{\Sigma\ 1\ \text{Ring} + 2\ \text{Ring Naphthenes}}{\Sigma\ 5\ \text{Ring} + 6\ \text{Ring Naphthenes}}$	R^2	S.E.E.
1-2	-0.0935	0.0377	-0.3138	0.0554	-0.0186	0.9352	0.1423
1-3	0.1219	-0.0001	-0.0722	-0.0708	-0.0934	0.9979	0.0264
1-4	0.1315	-0.0045	-0.0708	-0.0064	-0.0138	0.9956	0.0380
1-5	0.1292	-0.0047	-0.0934	-0.0035	-0.0129	0.9943	0.0434
1-6	0.0503	0.0002	0.0202	-0.0024	0.26×10^{-11}	0.9990	0.0181
1-7	0.1673	0.0105	0.0780	-0.1002	-0.0070	0.8019	0.2553
1-8	-0.2057	0.0129	-0.3672	0.1910	-0.0248	0.8719	0.2059
2-3	0.1103	0.0032	0.0956	-0.0423	-0.0049	0.9842	0.0779
2-4	0.0567	-0.0251	0.0003	0.0626	0.0001	0.9893	0.0642
2-5	0.0569	-0.0201	0.0780	0.0187	0.0084	0.9930	0.0541
2-6	0.0510	0.0003	0.0685	0.0007	0.70×10^{-11}	0.9949	0.0443
2-7	0.0394	-0.0378	0.2135	0.0088	0.0072	0.9355	0.1640
2-8	-0.0454	-0.0682	-0.0272	0.1978	-0.0033	0.9263	0.1685
3-4	-0.2918	-0.0124	-0.0516	0.0771	-0.0069	0.9843	0.0755
3-5	-0.4824	-0.0311	0.0259	0.0700	0.0007	0.9846	0.0758
3-6	0.1169	0.0057	0.0321	0.0073	-0.37×10^{-11}	0.9974	0.0307
3-7	-0.1062	-0.0065	0.1669	-0.0010	0.0028	0.9788	0.0890
3-8	-0.1014	-0.0024	0.0479	0.0198	0.0024	0.9979	0.0275
4-5	-0.1060	0.0345	0.3679	-0.2468	0.0429	0.9169	0.1762
4-6	0.1243	0.0085	0.0193	0.0062	-0.72×10^{-11}	0.9966	0.0352
4-7	-0.0662	0.0228	0.0214	-0.0500	-0.0019	0.9855	0.0737
4-8	-0.1242	0.0049	0.0218	0.0234	0.0011	0.9964	0.0361
5-6	0.1368	0.0067	0.0044	0.0120	-0.88×10^{-11}	0.9975	0.0306
5-7	-0.0633	0.0284	-0.0228	-0.0534	-0.0037	0.9844	0.0780
5-8	-0.1135	0.0043	0.0234	0.0198	0.0012	0.9969	0.0340
6-7	-0.0675	-0.0053	0.0316	0.0004	0.9×10^{-11}	0.9920	0.0548
6-8	-0.0565	-0.0018	0.0019	0.0085	0.16×10^{-11}	0.9996	0.0121
7-8	-0.0928	-0.0270	-0.0278	0.1115	-0.0017	0.9033	0.1900

R = Overall Correlation Coefficient
S.E.E. = Standard Error of Estimate

n_1 and n_2 = number of replicates in each oil population *

R = overall correlation coefficient

p = number of parameters used (5 for discriminant function)

The results of these calculations are summarized in Table 18.

All possible pairs of test oils considered are shown to be clearly distinguishable from each other. Most pairs have a vanishingly small probability of misclassification; a few are somewhat more difficult to distinguish, but still have extremely low probabilities of misclassification. The discriminant function developed for this set of oils is thus capable of discriminating between any two oil populations used in this study, even after these oils have been weathered (in laboratory simulators) for as long as 21 days under a variety of weathering conditions.

The same general procedure was used to estimate the probability that two oils (or populations of replicates of these oils) were the same. This was done by taking five replicate unweathered and 5 replicate weathered (different weathering conditions) samples of the same oil (Tia Juana Medium, or Oil 1 in our test) and comparing them using the five best indices (as well as all other preliminary indices) in the stepwise multiple regression program. The results showed that the two populations were indistinguishable. Multiple regression statistics for this comparison are presented in Appendix E.

7.4 Estimation of Confidence Levels for Oil Classification Using Bonferroni "t" Statistics

An alternate method of estimating the probability of misclassification of two oils (confidence of correct classification) is the Bonferroni multiple "t" equation which considers all five final compound indices and their variances simultaneously. The Bonferroni equation may be written in the following form (5):

$$U_i \in y_i \pm t_{\nu_i}^{\alpha/2k} s_i; \text{ with } p = 1 - \alpha \qquad (11)$$

---

* Both weathered and unweathered runs were used as replicates for comparison.

TABLE 18

PROBABILITY OF MISCLASSIFICATION OF PAIRS OF OILS

Oil Comparison	R^2	s_D	μ	Pm
1-2	0.935	0.144	3.46	<0.0003
1-3	0.998	0.027	18.26	Nil
1-4	0.996	0.039	12.71	Nil
1-5	0.994	0.045	11.10	Nil
1-6	0.999	0.019	26.50	Nil
1-7	0.802	0.238	2.10	0.017
1-8	0.872	0.199	2.51	0.006
2-3	0.984	0.083	6.05	Nil
2-4	0.989	0.068	7.32	Nil
2-5	0.993	0.058	8.58	Nil
2-6	0.995	0.047	10.58	Nil
2-7	0.935	0.171	2.92	0.003
2-8	0.926	0.173	2.89	0.003
3-4	0.984	0.079	6.36	Nil
3-5	0.985	0.073	6.30	Nil
3-6	0.997	0.030	15.52	Nil
3-7	0.979	0.093	5.39	Nil
3-8	0.998	0.028	17.31	Nil
4-5	0.917	0.178	2.81	<0.0025
4-6	0.997	0.037	13.56	Nil
4-7	0.985	0.077	6.48	Nil
4-8	0.996	0.038	13.24	Nil
5-6	0.997	0.032	15.51	Nil
5-7	0.984	0.082	6.09	Nil
5-8	0.997	0.036	13.96	Nil
6-7	0.992	0.057	8.70	Nil
6-8	0.999	0.013	39.03	Nil
7-8	0.903	0.190	2.63	<0.0043

Key

Number	Oil Identification
1	Tia Juana Medium Crude
2	Lago Crude
3	Grand Isle Mix Crude
4	Nigerian Crude
5	Zuitina Crude
6	No. 2 Fuel Oil
7	No. 4 Fuel Oil
8	No. 5 Fuel Oil

where $t_{\gamma_i}^{\alpha/2k}$ = the upper $\frac{\alpha}{2k}$ percentile points of the t distribution

y_i = normally distributed random variables (indices)

U_i = means of variables

γ_i = degrees of freedom

s_i = standard deviation of variables (indices)

α = probability, α' = reduced probability = $\frac{\alpha}{2k}$

k = number of variables (indices)

The upper $\frac{\alpha}{2k}$ percentile points of the t distribution ($t_{\gamma i}^{\alpha/2k}$) may be approximated by the following expression (Pearson's approximation)(5):

$$t_{\gamma_i}^{\alpha/2k} = t_{\gamma_i}^{\alpha'} = \frac{1}{4\gamma_i}\left[(g^{\alpha'})^3 + g^{\alpha'}\right] + g^{\alpha'} \qquad (12)$$

where $g^{\alpha'}$ = upper 100α' percent point of the normal N(0,1) distribution.

The steps required in applying the Bonferroni equation to estimate the confidence of distinguishing between two oils with certain characteristic indices y_i (based on the five indices developed for the oils in this program) are as follows:

- Select an overall probability level (α) which one would want the comparison to pass.
- Calculate the reduced probability level ($\alpha' = \frac{\alpha}{2k}$ where k = number of discriminators).
- Obtain $t_{\gamma}^{\alpha'}$ either from tables or Pearson's approximation, i.e., equation (12). For five indices, $\gamma = k - 1 = 4$ (this case).
- Obtain an estimate of the standard deviation of each index (s_i) from replicate analysis.
- Calculate $t_{\gamma_i}^{\alpha'} s_i$ for the five indices for the suspect oil (Oil 2).

- Calculate the acceptance intervals for the five indices, i.e., $y_i \pm t_{\gamma}^{\alpha'} s_i$ for suspect (Oil 2).
- If $\bar{y}_i$ (U_i) for the spill source (Oil 1, for example) lies outside any one of the five intervals calculated alone for the suspect, the hypothesis that the oils are the same is rejected. The probability of rejection (confidence that are different) is the originally assumed level for the calculation.
- By trial and error, different probability levels can be assumed to determine the cut-off point. For example, if α was assumed to be equal to 0.01 and all five indices for the spill oil (Oil 1, for example) were found to be outside each acceptance interval for the suspect oil (Oil 2, for example), the procedure could be repeated for lower assumed values of α (higher confidence levels) until only one index remained outside its respective acceptance interval.

The above technique was applied to the comparison of two cases where the oils in the program were fairly similar (as shown in Table 18 Section 7.3), Oils 1 and 7 and Oils 1 and 2. The assumed probability level for the calculations was $\alpha = 0.01$. Results are summarized as follows:

Results of Bonferroni Technique

Case 1 Oil 1 vs. Oil 2

$k = 5$, $\alpha = 0.01$ (assumed value), $\alpha' = 0.001$

Index	$\bar{y}_i$ (Oil 1)	y_i (Oil 2)	$t^{\alpha'} s_i$	$y_i + t_{\gamma}^{\alpha'} s_i$	$y_i - t_{\gamma}^{\alpha'} s_i$
Ni/V	7.79	4.6	0.77	5.37	3.83
$\frac{\text{Paraffins}}{\text{P + N}}$	34.13	17.3	13.48	30.78	3.82
$\frac{\text{5 Ring Naphthenes}}{\text{P + N}}$	2.78	4.28	1.89	6.17	2.39
$\frac{\text{nC20}}{\text{n Paraffins}/_{40}^{20}}$	14.87	11.0	1.21	12.2	9.79
$\frac{\text{1+2 Ring Naphthenes}}{\text{5+6 Ring Naphthenes}}$	11.62	5.52	10.17	15.7	0

Case 2 Oil 1 vs. Oil 7

$k = 5$, $\alpha = 0.01$ (assumed value), $\alpha' = 0.001$

Index	$\bar{y}_i$ (Oil 1)	y_i (Oil 7)	$t^{\alpha'} s_i$	$y_i + t_\gamma^{\alpha'} s_i$	$y_i - t_\gamma^{\alpha'} s_i$
Ni/V	7.79	6.8	0.77	6.03	7.57
$\frac{\Sigma \text{Paraffins}}{\Sigma P + N}$	34.13	35.1	13.48	21.6	48.6
$\frac{\Sigma 5 \text{ Ring Naphthenes}}{\Sigma P + N}$	2.78	1.50	1.89	3.39	0
$\frac{nC_{20}}{\Sigma n \text{ Paraffins}/^{20}_{40}}$	14.87	19.3	1.21	18.1	20.5
$\frac{\Sigma 1+2 \text{ Ring Naphthenes}}{\Sigma 5+6 \text{ Ring Naphthenes}}$	11.62	29.0	10.17	18.8	39.2

The results of the two examples given indicate that Oils 1 and 2 and Oils 1 and 7 are significantly different at the assumed confidence level of 99.0% (i.e., three indices for Oils 1 and 2 and two indices for Oils 1 and 7 are outside their Bonferroni acceptance limits). The procedure could have been repeated assuming a somewhat higher confidence level (lower probability) until only one index was outside its respective Bonferroni acceptance limits in each case. This would give the maximum confidence level of the oils being different.

7.5 Summary of System Application

In the application of this system to real spill situations, the following steps should be taken:

- Analyze replicate samples of a weathered oil spill source and all suspect sources as described in Section 6. Initially, we recommend at least five replicates.
- Select (about 26) preliminary compound indices that appear to aid in the discrimination of oil pairs by inspection of the resulting data. The application of individual "t" tests in considering potential indices is useful*.

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* It is difficult to estimate how widely applicable the 26 preliminary and final five compound indices selected for the oils used in this program are for other oils of different origin and character. This would have to be evaluated with other oils. Therefore, the general approach of preliminary, then final, index selection is recommended.

- Obtain the best discriminating indices by the application of discriminant function analysis as outlined in Section 7.2. (In the development of the discriminant functions, only the spilled oil sample(s) and each suspect source sample(s) are compared in pairs, i.e., it is not necessary to compare the suspect oils with each other.)

- Calculate the confidence levels that suspect oil sources are different from the spilled oil. Confidence levels for two oils being different can be obtained by either of the methods described in Sections 7.3 and 7.4, respectively. However, the Bonferroni technique appears more suitable to the oil spill identification problem.

- If any of the suspect oils does not develop a discriminant function, it will indicate that it is the same as the spill source. An estimate is then made of the probability of the spilled oil and the prime suspect being the same by comparing their discriminant indices and variances in their measurements*.

7.6 Discussion of Results and System Limitations

The results of this study indicate that certain specific (or groups of) chemical compounds, which are present in crude oils and refined oil products, can be used to distinguish between pairs of oils even after they have undergone extensive laboratory weathering. These chemical fingerprint indices include weight concentration ratios of V/Ni and high molecular weight (BP >400°F) paraffins, naphthenes and polynuclear aromatics. The five indices selected by discriminant function analysis for distinguishing among the eight different oils used in this study are specific to these oils--other specific indices may be preferred for the comparison of another group of oils. However, the methodology developed in this identification system should be generally applicable and should always select the best group of tags.

Laboratory weathering can only provide a limited simulation of the real weathering process. Thus, further studies are needed to test the system's ability to handle oils which have been weathered in the real marine environment. In addition, only a limited number of oils were tested in this program. The system should thus be evaluated with other oils of different physico-chemical nature.

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* Until a complete library of indices for all the World's crude oils and refined products is available, it would be virtually impossible to preclude the possibility of other oils having the same fingerprint as an apparent suspect.

At the present time, several replicate analysis on spill and suspect sources are required to make the results statistically reliable. A minimum of five replications, using each oil involved in a spill situation is recommended. This limitation would be relaxed as more data and experience in processing and analyzing other oils are acquired such that analysis variances could be reliably assumed.

The system, as presently developed, does not have the capability to distinguish between weathered crude oils and weathered residual fuels as general classes of petroleum products. However, it may distinguish between specific crude and a specific residual fuel (as it does between two different crudes). Further work is required to give the system the capability to make this distinction. This would involve the inclusion of more volatile n-paraffins ($<C_{20}$) in the tag responses.

The Bonferroni technique appears to be the preferred method of estimating statistical condifence levels that two oils are different.

SECTION 8

GENERAL EFFECTS OF LABORATORY WEATHERING

Although the chemical fingerprint indices developed in Section 7 were shown to be virtually unaffected by laboratory simulated weathering, significant changes in non-index oil components did take place. It is instructive to review these changes for they indicate that considerable "weathering" was affected in our laboratory simulation facility. General physical changes and changes resulting from the weathering processes of evaporation and oxidation are described in the following paragraphs.

8.1 General Physical Changes

Certain physical changes in the character of weathered oil samples were observed during the simulated weathering experiments. Crude oils generally became more viscous, and frothy with some localized discolorations. This can be seen in Figure 21 which shows the physical appearance of a typical crude oil (Tia Juana Medium) before and after 10 days of simulated weathering in the test facility described in Section 5 of the report. These changes were generally seen to a greater or lesser degree in the other crudes. Typical changes in a residual fuel under test are described in Figures 22 and 23.

The No. 2 distillate fuel, on the other hand, showed a somewhat different change in physical character during the weathering process. As indicated in Figures 24 and 25, the No. 2 fuel oil appeared to disperse at the surface in the sea water in the form of small globules after about 10 days of weathering.

These general physical changes indicated that significant weathering was effected by our test facility. Further evidence of weathering changes is presented in the following paragraphs.

8.2 Evaporation Effects

The effect of evaporation on the composition of a crude oil (Tia Juana Medium) and No. 4 and No. 5 residual fuel oils is shown in Figures 26, 27 and 28 respectively. A considerable loss of volatile components is indicated by the decrease in boiling point range for each weathered oil. G.C. distillation data obtained for weathered oil samples at 10 and 21 day intervals (No. 4 and No. 5 oils) show little difference in boiling point composition indicating that virtually all the light ends were lost within the 10-day weathering interval. The weathering simulator thus provided for significant evaporative weathering effects.

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CRUDE OIL BEFORE AND AFTER [illegible] WEATHERING

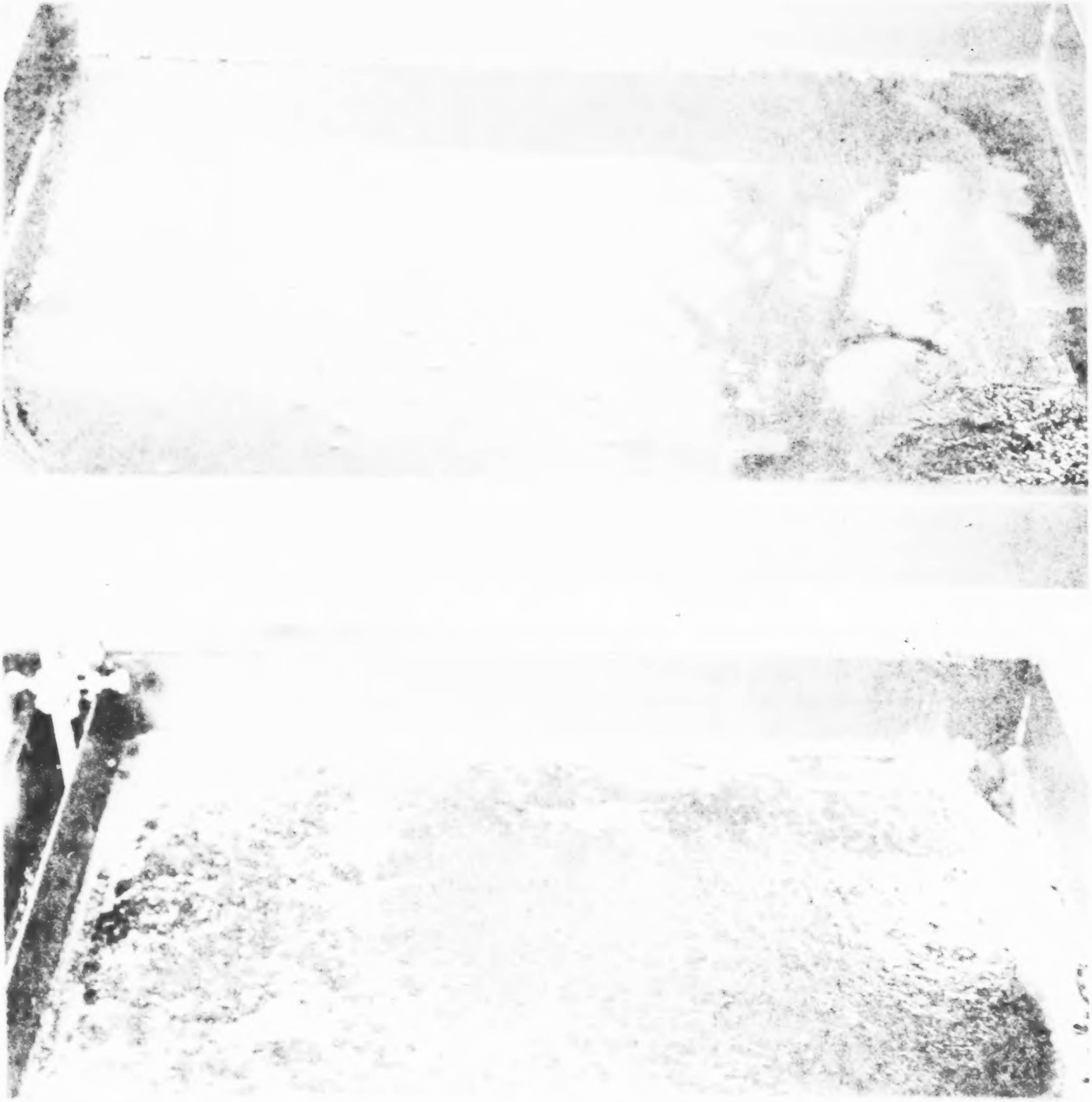


FIGURE 22

NO. 1 FUEL OIL BEFORE WEATHERING

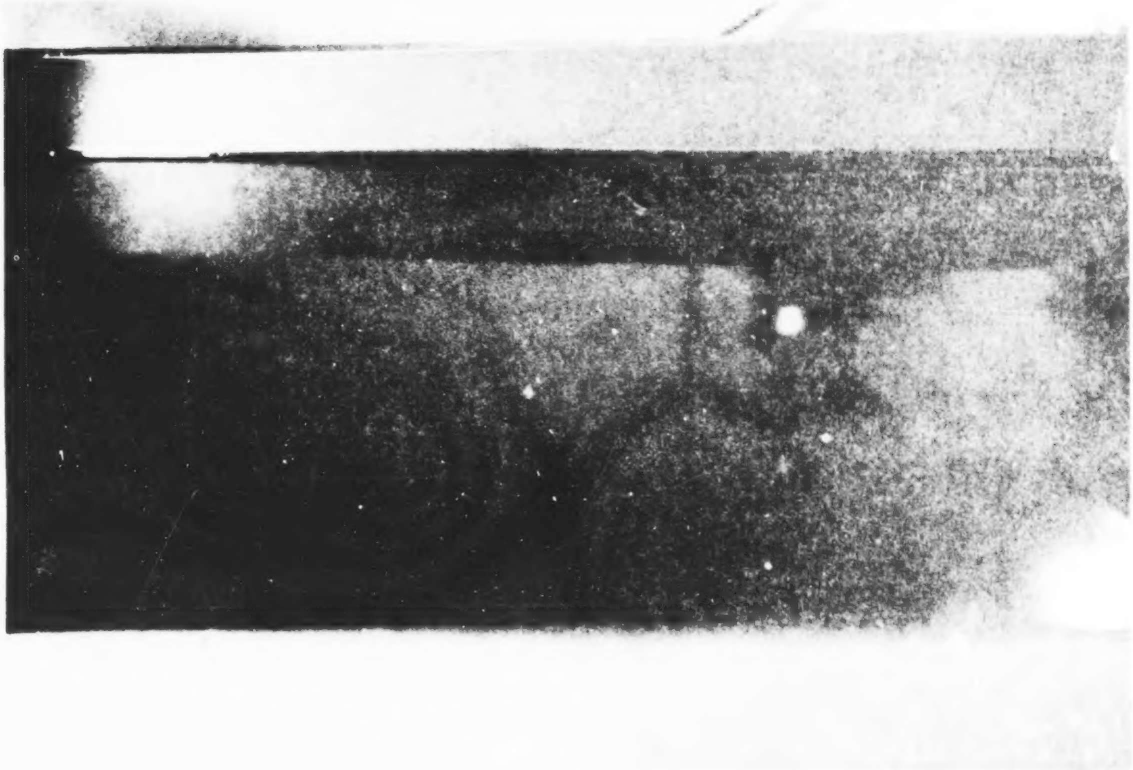


FIGURE 27

No. 5 FUEL OIL AFTER WEATHERING

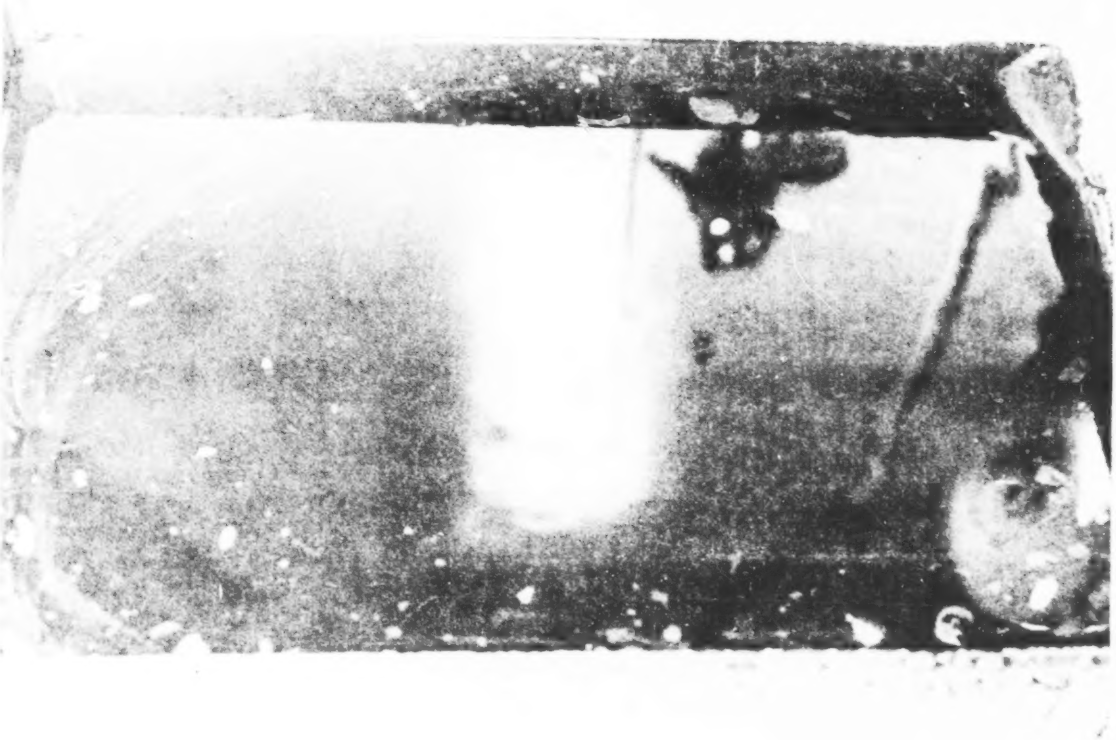


FIGURE 24

NO. 2 HEATING OIL BEFORE WEATHERING

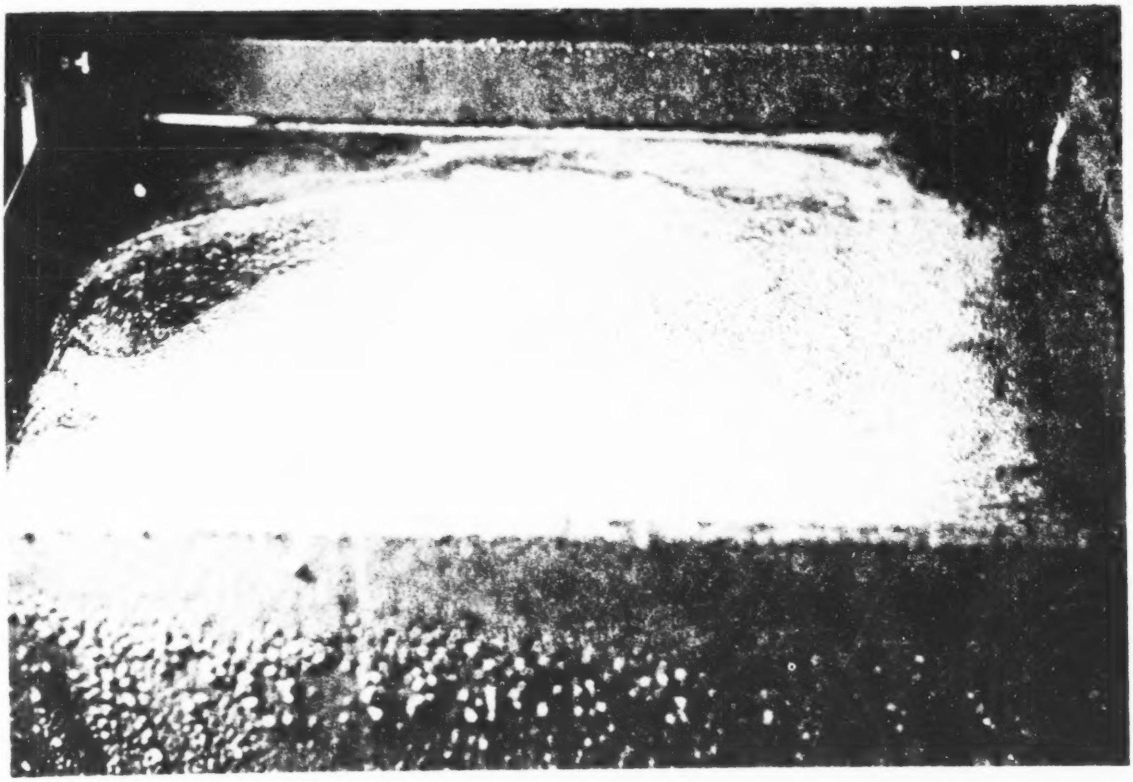


FIGURE 25

NO. 2 HEATING OIL AFTER WEATHERING

FIGURE 26

EFFECT OF EVAPORATION ON BOILING POINT
DISTRIBUTION OF TIA JUANA MEDIUM CRUDE OIL

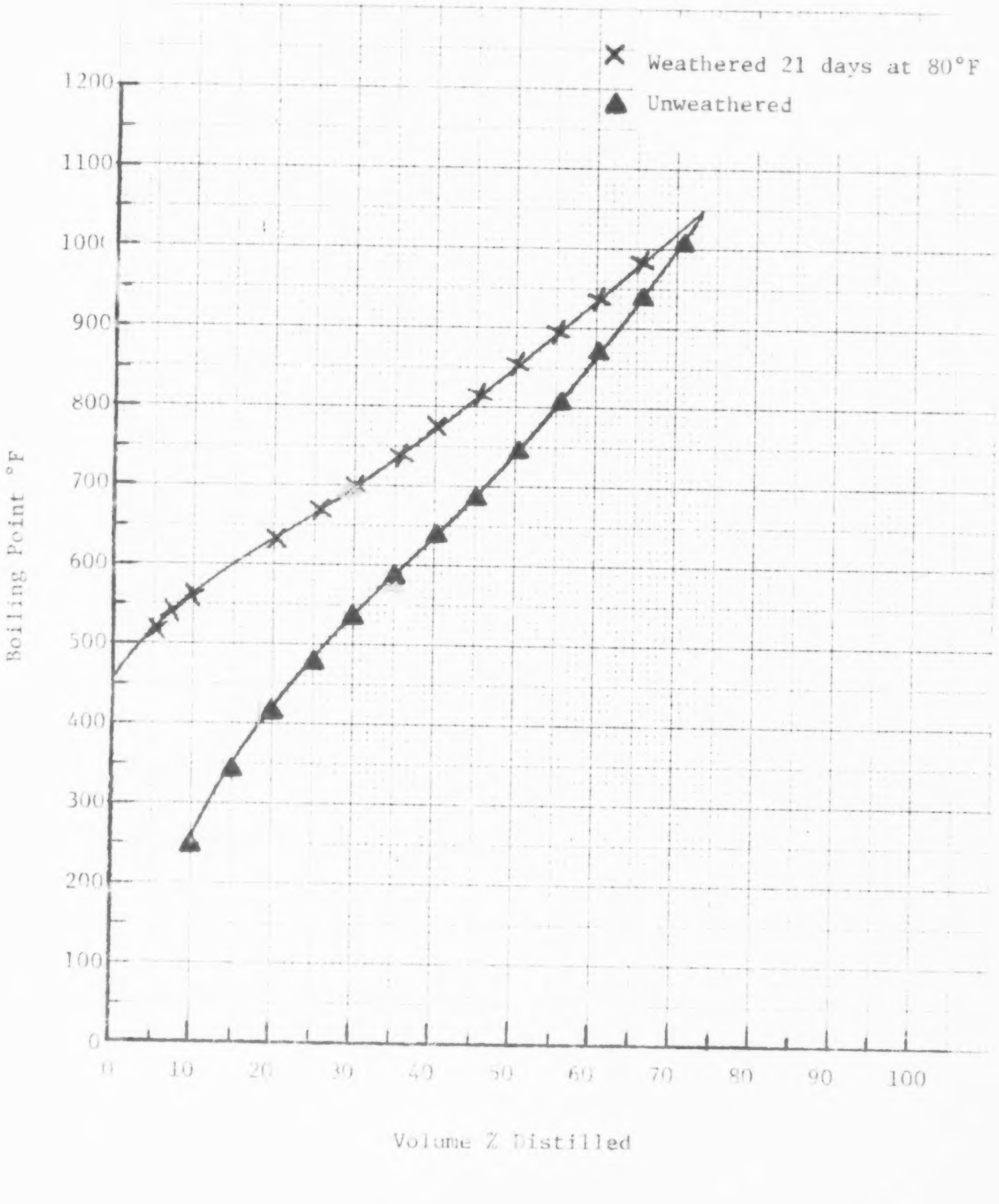


FIGURE 27

EFFECT OF EVAPORATION ON BOILING POINT DISTRIBUTION OF A NO. 4 FUEL OIL

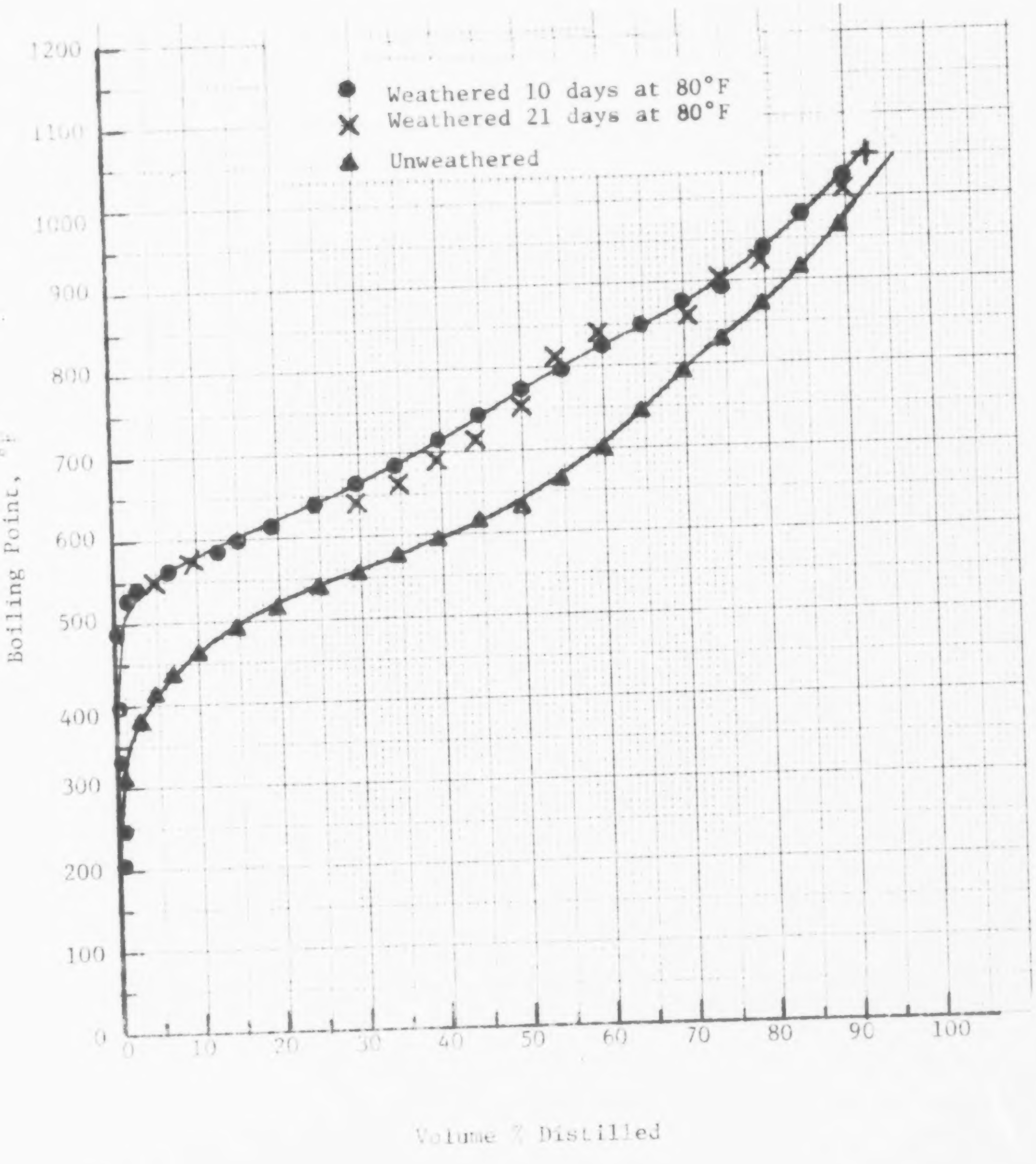
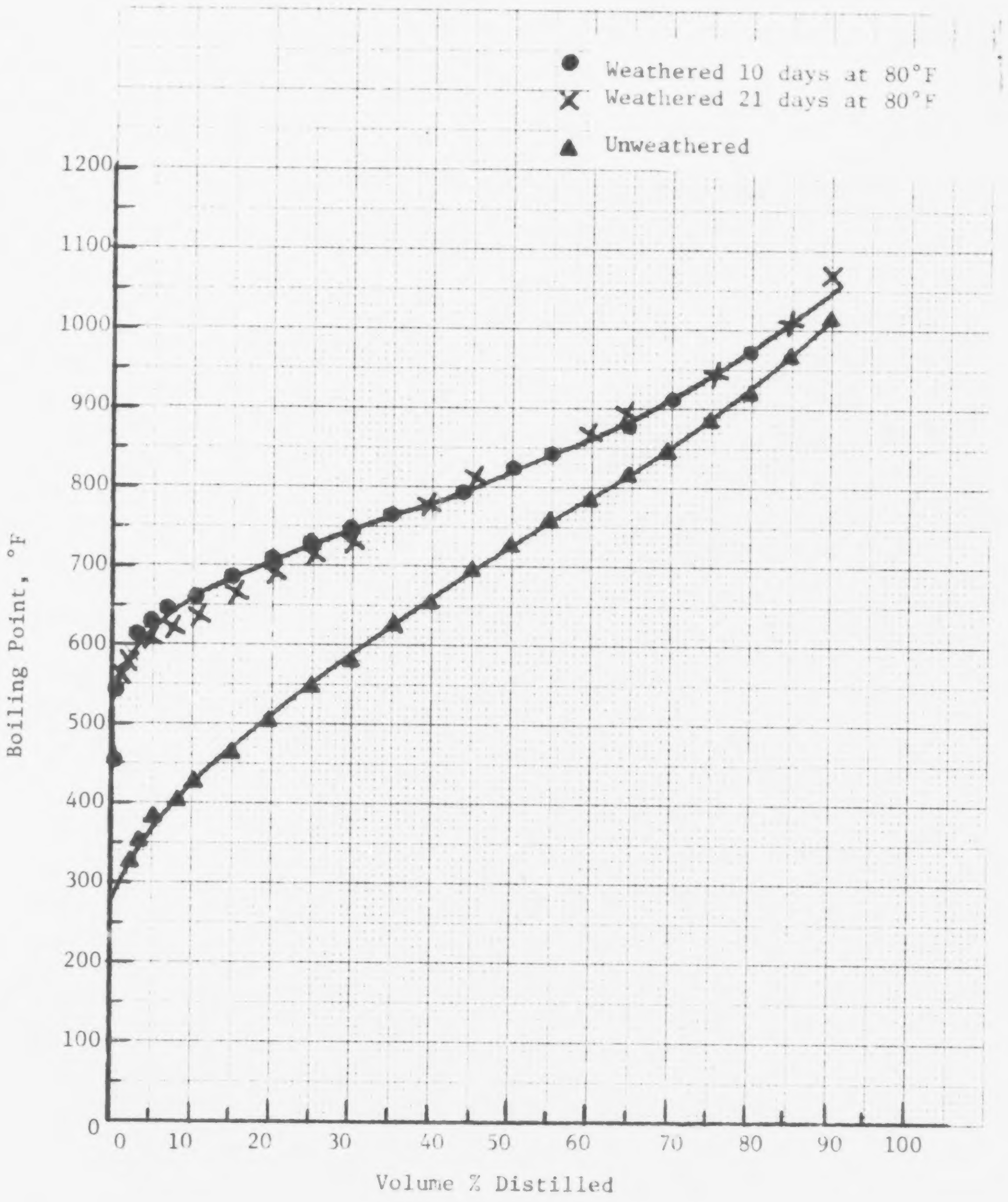


FIGURE 28

EFFECT OF EVAPORATION ON BOILING POINT DISTRIBUTION OF A NO. 5 FUEL OIL



8.3 Oxidation Effects

Significant oxidation was also observed to occur in non-fingerprint tag compounds during the oil spill identification weathering tests. This can best be seen with reference to Table 19 which shows an increase in concentration of oxygen bonds in weathered oil samples as indicated by an increase in infrared absorbance at 1700 cm^{-1} (the carbonyl bond). IR absorbances at 1600 cm^{-1} (aromatic C-H) and 1375 cm^{-1} ($-CH_3$) bonds for each set of samples are also presented for comparison.

TABLE 19

IR ANALYSIS OF WEATHERED OIL SAMPLES (*,+)

Tia Juana (Medium) Crude

Weathering Period (Days)	Absorbance (Arbitrary Units)			$\frac{1700}{1600}$	$\frac{1700}{1375}$
	1700 cm^{-1}	1600 cm^{-1}	1375 cm^{-1}		
0	4.0	37.0	36.5	0.108	0.109
10	24.0	35.5	24.5	0.677	0.982
21	28.5	31.5	24.0	0.905	1.186

No. 5 Fuel Oil

Weathering Period (Days)	1700 cm^{-1}	1600 cm^{-1}	1375 cm^{-1}	$\frac{1700}{1600}$	$\frac{1700}{1375}$
0	0	48.0	41.0	0	0
10	14.0	39.0	35.5	0.394	0.466
21	20.5	39.5	35.5	0.518	0.578

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* Weathered at 80°F over sea water in presence of UV lamp (on 2 hours/day).

+ IR obtained on crude, dried samples.

Infrared carbonyl absorbances are seen to increase markedly with an increase in weathering time for Tia Juana Crude and No. 5 Fuel Oils weathered at 80°F under high water mixing conditions. A slight concomitant decrease in the concentration of aromatic C-H bonds (1600 cm^{-1}) and CH_3 bonds (1375 cm^{-1}) after the first 10 days of weathering is also noted. Thus, it can be concluded that the weathering test facility used in this study provided the conditions for significant oxidation to occur even though the selected fingerprint indices were virtually unchanged during the test.

SECTION 9

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SECTION 10

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SECTION 11

APPENDICES

Appendix	Description
A	Sample Separation Material Balance Data
B	Summary of Oil Fingerprint Data
C	Gas Chromatic Distillation Data
D	Control Sample Statistics
E	Comparisons of Weathered and Unweathered Oils
F	[illegible] Gas Chromatograms

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APPENDIX A

SAMPLE SEPARATION
MATERIAL BALANCE DATA

			Composition in Weight %				
Computer* Code No.	Analytical No.	Oil Identification	Paraffins + Napthenes	Aromatics	Polars	Pentane Insolubles	ΣFraction
100000 **	524222	Tia Juana Medium Crude Oil	46.0	21.6	19.3	9.0	93.9
100001	524240		45.2	19.5	18.4	10.9	97.0
100002	524242		47.7	20.8	20.4	9.4	97.9
100003	524290		47.4	18.6	21.5	10.9	98.4
100004	248450		44.1	20.5	26.5	8.8	99.9
100005	248423		46.1	21.4	24.1	9.6	101.2
110559	248432		44.6	24.4	28.2	11.4	108.6
121551	578621		44.0	10.1	38.3	10.4	102.8
110801	584910		52.0	20.2	20.1	10.1	102.4
110809	525317		50.3	20.3	18.4	10.1	99.1
121801	584943		44.8	20.3	28.5	10.3	103.9
121809	525402		50.9	20.4	26.8	10.0	108.1
200000	578630	Lago Crude Oil	39.8	21.8	24.7	15.5	101.8
210559	578607		40.7	21.8	22.6	12.7	97.8
221551	578624		42.0	21.2	22.5	12.3	98.0
210809	525320		40.7	23.7	27.8	12.7	114.9
221809	525405		27.9	12.9	49.2	13.0	103.2
300000	578646	Grande Isle Mix Crude Oil	73.0	16.1	12.3	1.2	102.6
310559	578608		67.7	19.8	11.2	0.4	99.1
321551	598578		62.4	22.1	15.1	0.6	100.2
321809	581114		70.1	13.9	14.8	0.7	99.5
310809	584911		62.2	17.4	13.6	0.6	93.8
321801	24807		60.5	20.2	17.4	0.7	95.8
400020	578635	Nigerian Crude Oil	61.2	20.7	10.6	1.0	93.5
410559	578606		64.3	24.1	10.8	0.4	99.6
421559	578623		64.0	21.1	11.3	0.4	96.8
421551	598576		61.9	23.1	14.0	0.3	99.3
410801	588718		61.7	22.8	13.5	0.4	98.4
421801	248406		57.2	20.5	20.8	0.1	98.6
410809	524236		62.6	20.7	14.2	0.3	97.8
421809	581106		63.7	20.8	14.3	0.5	99.3
500000	578633	Zuitina Crude	66.1	12.1	15.2	3.1	96.5
510559	578605		73.5	14.0	11.2	2.3	102.0
521559	578622		72.4	13.6	10.9	2.3	99.2
510801	248418		67.9	11.1	17.0	1.8	97.8
521551	586030		71.7	13.5	14.3	1.5	100.0
510809	524231		70.3	14.4	12.2	1.6	98.5
521809	525403		71.7	14.7	12.2	1.6	100.2

*Computer Code Number Translation 1 10 80 9

1 — Oil Type
10 — Weathering Time, Days
80 — Weathering Temperature, °F
9 — Mix Condition (9=High, 1=Low)

**Replicate unweathered crudes.

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			Composition in Weight %				
Computer Code No.	Analytical No.	Oil Identification	Paraffins + Napthenes	Aromatics	Polars	Pentane Insolubles	Σ **Fraction**
600000	577727	No. 2. Heating Oil	49.7	46.6	0.0	0.2	96.5
610559	578610		57.8	39.5	1.3	0.02	98.5
621559	578626		64.5	29.7	2.6	0.2	97.0
621559	578628		65.8	30.2	2.6	0.2	102.8
621801	248416		62.9	23.3	12.3	0.2	98.7
621809	581110		65.6	27.4	5.6	0.2	98.8
610801	588723		63.8	27.7	6.9	0.5	98.9
610809	525324		59.6	35.3	3.6	0.8	99.3
700000	578650	No. 4 Fuel Oil	63.2	26.2	8.6	1.0	99.0
710559	525301		61.0	26.0	11.6	1.2	99.8
721551	598582		62.8	22.8	13.4	1.1	99.6
710809	525325		65.1	25.8	7.7	1.4	100.0
721809	525410		67.2	22.4	9.2	1.3	100.1
721801	248410		62.4	25.4	10.6	1.3	99.7
710801	588724		66.8	20.5	9.6	1.2	98.1
800000		No. 5 Fuel Oil					
810559	578609		64.2	20.4	12.1	5.8	102.5
821559	578626		61.7	20.6	11.9	5.9	100.1
821551	598579		53.8	24.1	21.3	5.4	104.6
810801	588721		59.8	23.5	14.0	6.1	103.4
810809	524239		58.5	23.1	14.4	1.1	97.1
821801	248110		54.8	22.1	20.7	5.8	103.4
821809	581104		61.5	20.6	16.4	5.8	103.3

Computer No. 100001
Analytical No. 526938

APPENDIX B

SUMMARY OF OIL FINGERPRINT DATA

Computer Index	Formula	Numerical Value	Computer Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.7	I_{19}	$\frac{C_{27}}{\Sigma nParaffin_{c=40}^{c=20}}$	6.1
I_2	$\frac{S}{N}$	6.2	I_{20}	$\frac{C_{30}}{\Sigma nParaffin_{c=40}^{c=20}}$	3.2
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	21.64	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	4.6
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}_{c=36}^{c=20}$	11.40	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.45
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	12.74	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.42
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}_{c=36}^{c=20}$	8.54			
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	11.43	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.40
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	7.90	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.69
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.97	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	12.40
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P + N)}$	32.33			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	11.32			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	6.11			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	2.50			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin_{c=40}^{c=20}}$	14.8			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin_{c=40}^{c=20}}$	11.7			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin_{=40}^{c=20}}$	7.9			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin_{c=40}^{c=20}}$	8.4			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin_{c=40}^{c=20}}$	6.5			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. 100002
Analytical No. 578640

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.4	I_{19}	$\frac{C_{27}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	5.7
I_2	$\frac{S}{N}$	6.2	I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	3.6
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	20.79	I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.0
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	12.15	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.45
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	13.16	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.42
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	9.38	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.39
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	11.65			
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	8.17	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.53
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	8.69	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	8.10
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P+N)}$	34.92			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P+N)}$	11.17			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P+N)}$	6.89			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P+N)}$	3.30			
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	14.6			
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	11.5			
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.0			
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.4			
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.1			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. 121559
Analytical No. 578621

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.0
I_2	$\frac{S}{N}$	6.0
I_3	$\frac{\Sigma C_nH_{2n-6}}{\Sigma\text{Aromatic}}$	24.53
I_4	$\frac{\Sigma C_nH_{2n-6}}{\Sigma\text{Aromatics}}{}_{c=36}^{c=20}$	12.9
I_5	$\frac{\Sigma C_nH_{2n-10}}{\Sigma\text{Aromatic}}$	14.92
I_6	$\frac{\Sigma C_nH_{2n-10}}{\Sigma\text{Aromatic}}{}_{c=36}^{c=20}$	10.0
I_7	$\frac{\Sigma C_nH_{2n-14}}{\Sigma\text{Aromatics}}$	12.07
I_8	$\frac{\Sigma C_nH_{2n-16}}{\Sigma\text{Aromatics}}$	6.59
I_9	$\frac{\Sigma C_nH_{2n-18}}{\Sigma\text{Aromatics}}$	3.59
I_{10}	$\frac{\Sigma\text{nParaffins}}{\Sigma(P+N)}$	36.17
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	11.75
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	6.80
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	2.69
I_{14}	$\frac{C20}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	13.4
I_{15}	$\frac{C21}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	11.0
I_{16}	$\frac{C24}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	10.0
I_{17}	$\frac{C25}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	9.1
I_{18}	$\frac{C26}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	6.7

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	5.5
I_{20}	$\frac{C30}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	4.2
I_{21}	$\frac{C_{31}}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	4.2
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.16
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.34
I_{24}	$\frac{\Sigma\ C_nH_{2n-6}}{\Sigma\ C_nH_{2n-18}}$	6.84
I_{25}	$\frac{\Sigma\ C_nH_{2n-6}+\Sigma C_nH_{2n-18}}{C_nH_{2n-14}}$	2.21
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	10.6

Sample History

Oil Type - crude
Origin - Tia Juana Medium
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - High mix

Computer No. 110551
Analytical No. 524667

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.0	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	5.0
I_2	$\frac{S}{N}$	6.0	I_{20}	$\frac{C_{30}}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	4.0
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	21.2	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	4.0
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	13.3	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.1
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	13.0	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.60
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	9.10	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.4
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	12.0	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.5
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	9.0	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	8.0
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	8.0			
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	34.1			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	11.0			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	6.5			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.1			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	16.0			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	12.3			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	8.7			
I_{17}	$\frac{C25}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	9.0			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	6.0			

Sample History

Oil Type - crude
Origin - Tia Juana Medium
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - Low mix

Computer No. 100003
Analytical No. 578643

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.9	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.9
I_2	$\frac{S}{N}$	6.7	I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.2
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	21.38	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.9
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	11.58	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.53
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	12.61	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.36
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	8.50	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.45
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	11.66	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.57
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	8.06	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	6.55
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.72			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	39.48			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	10.46			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	6.89			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.43			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	14.3			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	11.1			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.2			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.1			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.6			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. [illegible]
Analytical No. [illegible]

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	[illegible]	I_{19}	$\frac{C27}{\Sigma nParaffin_{c=40}^{c=20}}$	[illegible]
I_2	$\frac{[illegible]}{N}$	[illegible]	I_{20}	$\frac{C29}{\Sigma nParaffin_{c=40}^{c=20}}$	[illegible]
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}$	[illegible]	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	[illegible]
I_4	$\frac{\Sigma CnH_{2n-8}}{\Sigma Aromatics}{}_{c=40}^{c=20}$	11.77	I_{22}	$\frac{\Sigma C_{20}+C_{21}+C_{22}}{\Sigma C_{30}+C_{31}+C_{32}}$	[illegible]
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatics}$	13.18	I_{23}	$\frac{\Sigma C_{20}+C_{21}+C_{22}+C_{23}+C_{24}+C_{25}}{\Sigma C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.42
I_6	$\frac{\Sigma CnH_{2n-12}}{\Sigma Aromatics}{}_{c=40}^{c=20}$	9.47	I_{24}	$\frac{\Sigma CnH_{2n-6}}{\Sigma CnH_{2n-18}}$	2.41
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	11.56	I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.33
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.13	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	6.82
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.62			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	34.21			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	11.24			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	7.39			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.62			
I_{14}	$\frac{C20}{\Sigma nParaffin_{c=40}^{c=20}}$	14.40			
I_{15}	$\frac{C21}{\Sigma nParaffin_{c=40}^{c=20}}$	11.7			
I_{16}	$\frac{C24}{\Sigma nParaffin_{c=40}^{c=20}}$	8.0			
I_{17}	$\frac{C25}{\Sigma nParaffin_{c=40}^{c=20}}$	7.7			
I_{18}	$\frac{C26}{\Sigma nParaffin_{c=40}^{c=20}}$	6.1			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I_2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I_3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I_4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I_5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I_6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I_7	[illegible]	11.41	[illegible]	$\frac{\Sigma(C_nH_{2n-?})+\Sigma(C_nH)_{2n-18}}{C_nH_{2n+2}}$	[illegible]
I_8	[illegible]	[illegible]			
I_9	[illegible]	[illegible]	[illegible]	Σ-1 Ring+2 Ring Naphthenes Σ-3 Ring+4 Ring Naphthenes	4.8
I_{10}	$\frac{\Sigma \text{ Paraffins}}{\Sigma(P+N)}$	[illegible]			
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	1.84			
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	[illegible]			
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	[illegible]			
I_{14}	$\frac{C20}{\Sigma \text{Paraffin}_{c=40}^{c=20}}$	[illegible]			
I_{15}	$\frac{C21}{\Sigma \text{Paraffin}_{c=40}^{c=20}}$	[illegible]			
I_{16}	$\frac{C26}{\Sigma \text{Paraffin}_{c=40}^{c=20}}$	8.8			
I_{17}	$\frac{C31}{\Sigma \text{Paraffin}_{c=40}^{c=20}}$	8.3			
I_{18}	$\frac{C35}{\Sigma \text{Paraffin}_{c=40}^{c=20}}$	[illegible]			

Oil Type [illegible]
[illegible]
[illegible]
Gathering Temperature [illegible]
Mixing Condition [illegible]

Computer No. [illegible]
Analytical No. [illegible]

Index	Formula	Numerical Value	Index	Formula	[illegible] Value
I_1	[illegible]	[illegible]	I_{19}	$\frac{C_{27}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]
I_2	[illegible]	[illegible]	I_{20}	$\frac{C_{30}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]
I_3	[illegible]	[illegible]	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]
I_4	[illegible]	[illegible]	I_{22}	[illegible]	[illegible]
I_5	[illegible]	[illegible]	I_{23}	$\frac{\Sigma C_{20}+C_{21}+C_{22}+\ldots}{\Sigma C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.60
I_6	[illegible]	[illegible]	I_{24}	$\frac{\Sigma CnH_{2n-6}}{\Sigma CnH_{2n-18}}$	[illegible]
I_7	[illegible]	[illegible]	I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	[illegible]
I_8	[illegible]	[illegible]	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	[illegible]
I_9	[illegible]	[illegible]			
I_{10}	$\frac{nParaffins}{\Sigma(P+N)}$	[illegible]			
I_{11}	$\frac{\Sigma\text{ 1 Ring Naphthenes}}{\Sigma(P+N)}$	[illegible]			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	[illegible]			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	[illegible]			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]			
I_{16}	$\frac{C_{22}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]			
I_{17}	$\frac{C_{23}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]			
I_{18}	$\frac{C_{24}}{\Sigma nParaffin_{c=20}^{c=40}}$	[illegible]			

Sample History

Oil Type - crude
Origin - [illegible]
Weathering [illegible] - [illegible]
Weathering Temperature, °F - [illegible]
Mixing condition - low mix

Computer No. [illegible]
Analytical No. [illegible]

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	[illegible]	[illegible]	I_{19}	$\frac{C27}{\Sigma nParaffin}{}_{c=40}^{c=20}$	[illegible]
I_2	[illegible]	[illegible]	I_{20}	$\frac{C29}{\Sigma nParaffin}{}_{c=40}^{c=20}$	[illegible]
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	[illegible]	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	6.8
I_4	$\frac{\Sigma CnH_{2n-8}}{\Sigma Aromatics}{}^{c=20}$	11.31	I_{22}	$\frac{\Sigma C_{30}+C_{31}+C_{32}}{\Sigma C_{30}+C_{31}+C_{32}}$	3.78
I_5	$\frac{\Sigma CnH_{2n-12}}{\Sigma Aromatic}{}_{c=20}$	12.23	I_{23}	$\frac{\Sigma C_{28}+C_{29}+C_{30}+C_{31}+C_{32}}{\Sigma C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.47
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	[illegible]	I_{24}	$\frac{\Sigma CnH_{2n-6}}{\Sigma CnH_{2n-18}}$	3.13
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	13.20	I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.10
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	8.49	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	11.30
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	6.70			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma(P+N)}$	36.20			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	11.70			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	6.62			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	[illegible]			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}_{c=40}^{c=20}$	14.[illegible]			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}_{c=40}^{c=20}$	11.4			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}_{c=40}^{c=20}$	7.6			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	7.6			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	6.[illegible]			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. [illegible]
Analytical No. [illegible]

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	9.2	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	5.8
I_2	$\frac{S}{N}$	6.6	I_{20}	$\frac{C30}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	6.1
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	21.55	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	3.6
I_4	$\frac{\Sigma CnH_{2n-8}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	14.23	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.74
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	12.93	I_{23}	$\frac{\Sigma\ C20+C21+C22+C30+C31+C32}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.41
I_6	$\frac{\Sigma CnH_{2n-12}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	8.64	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.68
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	11.99	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.46
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	8.62	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	24.9
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	8.05			
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P + N)}$	14.76			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	1?.00			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	6.57			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	1.76			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	14.6			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	11.?			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	8.?			
I_{17}	$\frac{C_{25}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	7.9			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	6.6			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - 21
Weathering Temperature, °F - [illegible]
Mixing Condition - Low

Computer No. 110801
Analytical No. 588716

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.6
I_2	$\frac{S}{N}$	6.1
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	21.27
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}_{c=36}^{c=20}$	13.70
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	12.28
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}_{c=36}^{c=20}$	8.86
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.58
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.07
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.45
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma (P + N)}$	34.40
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	11.91
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	6.81
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	2.22
I_{14}	$\frac{C_{20}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	14.2
I_{15}	$\frac{C_{21}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	11.3
I_{16}	$\frac{C_{24}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	8.3
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}_{c=40}^{c=26}$	7.9
I_{18}	$\frac{C_{26}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	6.6
I_{19}	$\frac{C_{27}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	6.0
I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	4.3
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	3.8
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.42
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.40
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.53
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.36
I_{26}	$\frac{\Sigma\text{-}1\ Ring+2\ Ring\ Naphthenes}{\Sigma\text{-}5\ Ring+6\ Ring\ Naphthenes}$	15.7

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 110809
Analytical No. 524248

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.8
I_2	$\frac{S}{N}$	6.3
I_3	$\frac{\Sigma \mathrm{CnH}_{2n-6}}{\Sigma \mathrm{Aromatic}}$	21.23
I_4	$\frac{\Sigma \mathrm{CnH}_{2n-6}}{\Sigma \mathrm{Aromatics}}{}_{c=36}^{c=20}$	13.21
I_5	$\frac{\Sigma \mathrm{CnH}_{2n-10}}{\Sigma \mathrm{Aromatic}}$	12.60
I_6	$\frac{\Sigma \mathrm{CnH}_{2n-10}}{\Sigma \mathrm{Aromatic}}{}_{c=36}^{c=20}$	9.07
I_7	$\frac{\Sigma \mathrm{CnH}_{2n-14}}{\Sigma \mathrm{Aromatics}}$	12.31
I_8	$\frac{\Sigma \mathrm{CnH}_{2n-16}}{\Sigma \mathrm{Aromatics}}$	9.00
I_9	$\frac{\Sigma \mathrm{CnH}_{2n-18}}{\Sigma \mathrm{Aromatics}}$	8.72
I_{10}	$\frac{\Sigma_n \mathrm{Paraffins}}{\Sigma (P + N)}$	34.05
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	11.01
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	6.51
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.05
I_{14}	$\frac{C_{20}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	16.1
I_{15}	$\frac{C_{21}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	12.3
I_{16}	$\frac{C_{24}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	8.7
I_{17}	$\frac{C_{25}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	8.7
I_{18}	$\frac{C_{26}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	6.0
I_{19}	$\frac{C_{27}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	4.8
I_{20}	$\frac{C_{30}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	3.5
I_{21}	$\frac{C_{31}}{\Sigma \mathrm{nParaffin}}{}_{c=40}^{c=20}$	3.5
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.1
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.55
I_{24}	$\frac{\Sigma\ \mathrm{CnH}_{2n-6}}{\Sigma\ \mathrm{CnH}_{2n-18}}$	2.43
I_{25}	$\frac{\Sigma\ \mathrm{CnH}_{2n-6}+\Sigma \mathrm{CnH}_{2n-18}}{\mathrm{CnH}_{2n-14}}$	2.44
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	7.81

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - HM

Computer No. 121801
Analytical No. 586027

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.0
I_2	$\frac{S}{N}$	5.9
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	21.76
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	14.63
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}\ {}_{c=20}$	12.67
I_6	$\frac{\Sigma CnH_{2n-10}\ c=36}{\Sigma Aromatic}$	9.58
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.86
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	8.90
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	7.62
I_{10}	$\frac{\Sigma n Paraffins}{\Sigma\ (P + N)}$	31.88
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma (P + N)}$	11.81
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma (P + N)}$	6.91
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma (P + N)}$	2.59
I_{14}	$\frac{C_{20}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	15.2
I_{15}	$\frac{C_{21}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	12.7
I_{16}	$\frac{C_{24}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	8.4
I_{17}	$\frac{C_{25}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	8.3
I_{18}	$\frac{C_{26}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	6.7
I_{19}	$\frac{C_{27}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	7.2
I_{20}	$\frac{C_{30}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	3.5
I_{21}	$\frac{C_{31}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	3.5
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.12
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.42
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.86
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.29
I_{26}	$\frac{\Sigma\text{-}1\ Ring+2\ Ring\ Naphthenes}{\Sigma\text{-}5\ Ring+6\ Ring\ Naphthenes}$	12.50

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 121809
Analytical No. 599393

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.6	I_{19}	$\frac{C27}{\Sigma nParaffin_{c=40}^{c=20}}$	5.3
I_2	$\frac{S}{N}$	5.6	I_{20}	$\frac{C_{30}}{\Sigma nParaffin_{c=40}^{c=20}}$	3.6
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	21.17	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	3.9
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}_{c=36}^{c=20}$	11.16	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.73
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	11.31	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.51
I_6	$\frac{\Sigma CnH_{2n-10}{}_{c=36}^{c=20}}{\Sigma Aromatic}$	6.82	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.48
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	13.24	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.25
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.22	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	10.90
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.55			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	33.07			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	11.31			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	6.50			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	2.67			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin_{c=40}^{c=20}}$	16.00			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin_{c=40}^{c=20}}$	11.7			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin_{c=40}^{c=20}}$	8.2			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin_{c=40}^{c=20}}$	8.7			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin_{c=40}^{c=20}}$	6.3			

Sample History

Oil Type - Crude
Origin - Tia Juana Medium
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 200000
Analytical No. 578630

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	5.6
I_2	$\frac{S}{N}$	6.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	18.86
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	11.17
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	13.92
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	9.59
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	12.54
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	8.87
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	9.39
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma (P + N)}$	16.60
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma (P + N)}$	16.60
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma (P + N)}$	10.50
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma (P + N)}$	4.50
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	11.30
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.80
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.50
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.90
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.20
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.90
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	2.90
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.30
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	1.85
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.30
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.01
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.25
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	7.27

Sample History

Oil Type - Crude
Origin - Lago
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. 210559
Analytical No. 578607

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.2
I_2	$\frac{S}{N}$	6.3
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.95
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}^{c=20}_{c=36}$	11.46
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	13.94
I_6	$\frac{\Sigma CnH_{2}n-10}{\Sigma Aromatic}{}^{c=20}_{c=36}$	9.69
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	12.60
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	9.14
I_9	$\frac{\Sigma CnH_{2}n-18}{\Sigma Aromatics}$	9.43
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	23.82
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	16.45
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	9.17
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	3.60
I_{14}	$\frac{C20}{\Sigma nParaffin^{c=20}_{c=40}}$	12.50
I_{15}	$\frac{C21}{\Sigma nParaffin^{c=20}_{c=40}}$	10.50
I_{16}	$\frac{C24}{\Sigma nParaffin^{c=20}_{c=40}}$	7.30
I_{17}	$\frac{C25}{\Sigma nParaffin^{c=20}_{c=40}}$	8.70
I_{18}	$\frac{C26}{\Sigma nParaffin^{c=20}_{c=40}}$	5.50
I_{19}	$\frac{C27}{\Sigma nParaffin^{c=20}_{c=40}}$	6.20
I_{20}	$\frac{C30}{\Sigma nParaffin^{c=20}_{c=40}}$	2.20
I_{21}	$\frac{C31}{\Sigma nParaffin^{c=20}_{c=40}}$	6.20
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.37
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.45
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.01
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.25
I_{26}	$\frac{\Sigma-1\ Ring+2\ Ring\ Naphthenes}{\Sigma-5\ Ring+6\ Ring\ Naphthenes}$	9.35

Sample History

Oil Type - Crude
Origin - Lago
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 221557
Analytical No. 598577

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.3
I_2	$\frac{S}{N}$	6.5
I_3	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatic}}$	19.70
I_4	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	12.69
I_5	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}$	14.07
I_6	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	10.32
I_7	$\frac{\Sigma C_nH_{2n-14}}{\Sigma \text{Aromatics}}$	12.10
I_8	$\frac{\Sigma C_nH_{2n-16}}{\Sigma \text{Aromatics}}$	8.68
I_9	$\frac{\Sigma C_nH_{2n-18}}{\Sigma \text{Aromatics}}$	8.86
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P + N)}$	18.31
I_{11}	$\frac{\Sigma\ 3 \text{ Ring Naphthenes}}{\Sigma(P + N)}$	16.57
I_{12}	$\frac{\Sigma\ 4 \text{ Ring Naphthenes}}{\Sigma(P + N)}$	9.64
I_{13}	$\frac{\Sigma\ 5 \text{ Ring Naphthenes}}{\Sigma(P + N)}$	3.17
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	11.1
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	9.9
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.9
I_{17}	$\frac{C25}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.1
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	7.1

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	5.9
I_{20}	$\frac{C30}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	5.5
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	5.1
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.21
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.26
I_{24}	$\frac{\Sigma\ C_nH_{2n-6}}{\Sigma\ C_nH_{2n-18}}$	2.22
I_{25}	$\frac{\Sigma\ C_nH_{2n-6}+\Sigma C_nH_{2n-18}}{C_nH_{2n-14}}$	2.37
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	14.8

Sample History

Oil Type - Crude
Origin - Lago
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - Low Mix

Computer No. 210809
Analytical No. 525320

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.00	I_{19}	$\frac{C27}{\Sigma nParaffin}{}_{c=40}^{c=20}$	5.20
I_2	$\frac{S}{N}$	6.10	I_{20}	$\frac{C30}{\Sigma nParaffin}{}_{c=40}^{c=20}$	2.57
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	20.06	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	4.73
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}_{c=36}^{c=20}$	11.85	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.08
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	13.38	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.33
I_6	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}{}_{c=36}^{c=20}$	9.41	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.09
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.17	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.45
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	8.97	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	8.00
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	9.62			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	20.09			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	15.14			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	9.69			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	4.39			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}_{c=40}^{c=20}$	12.40			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}_{c=40}^{c=20}$	10.40			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}_{c=40}^{c=20}$	8.40			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}_{c=40}^{c=20}$	9.50			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}_{c=40}^{c=20}$	6.80			

Sample History

Oil Type - Crude
Origin - Lago
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 221809
Analytical No. 525405

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	4.6	I_{19}	$\frac{C27}{\Sigma nParaffin_{c=40}^{c=20}}$	7.0
I_2	$\frac{S}{N}$	5.4	I_{20}	$\frac{C30}{\Sigma nParaffin_{c=40}^{c=20}}$	3.0
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	19.13	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	7.0
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}_{c=36}^{c=20}$	14.50	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	1.90
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	15.64	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.30
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}_{c=36}^{c=20}$	12.50	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	3.3
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	13.28	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.90
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	8.95	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	5.52
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	5.82			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P+N)}$	17.30			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	16.73			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	11.18			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	4.28			
I_{14}	$\frac{C20}{\Sigma nParaffin_{c=40}^{c=20}}$	11.0			
I_{15}	$\frac{C21}{\Sigma nParaffin_{c=40}^{c=20}}$	9.0			
I_{16}	$\frac{C24}{\Sigma nParaffin_{c=40}^{c=20}}$	8.0			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin_{c=40}^{c=20}}$	9.0			
I_{18}	$\frac{C26}{\Sigma nParaffin_{c=40}^{c=20}}$	6.0			

Sample History

Oil Type - Crude
Origin - Lago
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mi.

Computer No. 3-00-00-0
Analytical No. 578646

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.25	I_{19}	$\frac{C_{27}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	4.67
I_2	$\frac{S}{N}$	3.90	I_{20}	$\frac{C_{30}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	2.83
I_3	$\frac{\Sigma \mathrm{CnH}_{2n-6}}{\Sigma \mathrm{Aromatic}}$	18.06	I_{21}	$\frac{C_{31}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	4.25
I_4	$\frac{\Sigma \mathrm{CnH2n-6}}{\Sigma \mathrm{Aromatics}}{}^{c=20}_{c=36}$	7.51	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.29
I_5	$\frac{\Sigma \mathrm{CnH2n-10}}{\Sigma \mathrm{Aromatic}}$	13.92	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.83
I_6	$\frac{\Sigma \mathrm{CnH2n-10}}{\Sigma \mathrm{Aromatic}}{}^{c=20}_{c=36}$	6.85	I_{24}	$\frac{\Sigma\ \mathrm{CnH}_{2n-6}}{\Sigma\ \mathrm{CnH}_{2n-18}}$	2.19
I_7	$\frac{\Sigma \mathrm{CnH2n-14}}{\Sigma \mathrm{Aromatics}}$	11.70			
I_8	$\frac{\Sigma \mathrm{CnH2n-16}}{\Sigma \mathrm{Aromatics}}$	8.54	I_{25}	$\frac{\Sigma\ \mathrm{CnH}_{2n-6}+\Sigma \mathrm{CnH}_{2n-18}}{\mathrm{CnH}_{2n-14}}$	2.25
I_9	$\frac{\Sigma \mathrm{CnH}_{2n-18}}{\Sigma \mathrm{Aromatics}}$	8.25	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	5.96
I_{10}	$\frac{\Sigma_n \mathrm{Paraffins}}{\Sigma\ (P + N)}$	29.94			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	12.34			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	9.70			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	4.51			
I_{14}	$\frac{C_{20}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	19.23			
I_{15}	$\frac{C_{21}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	13.24			
I_{16}	$\frac{C_{24}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	7.40			
I_{17}	$\frac{C_{25}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	7.72			
I_{18}	$\frac{C_{26}}{\Sigma \mathrm{nParaffin}}{}^{c=20}_{c=40}$	5.52			

Sample History

Oil Type - Crude
Origin - Grande Isle Mix
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. [illegible]
Analytical No. [illegible]

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	[illegible]	I_{19}	$\frac{C_{27}}{\Sigma nParaffin_{c=40}^{c=20}}$	[illegible]
I_2	$\frac{S}{N}$	3.61	I_{20}	$\frac{C_{30}}{\Sigma nParaffin_{c=40}^{c=20}}$	[illegible]
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.01	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	[illegible]
I_4	$\frac{\Sigma CnH_{2n-8}}{\Sigma Aromatics}{}_{c=36}^{c=20}$	11.98	I_{22}	$\frac{\Sigma C_{20}+C_{21}+C_{22}}{\Sigma C_{30}+C_{31}+C_{32}}$	[illegible]
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	14.72	I_{23}	$\frac{\Sigma C_{20}+C_{21}+C_{22}+C_{23}}{\Sigma C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.60
I_6	$\frac{\Sigma CnH_{2n-12}}{\Sigma Aromatic}{}_{c=36}^{c=20}$	[illegible]	I_{24}	$\frac{\Sigma CnH_{2n-6}}{\Sigma CnH_{2n-18}}$	2.07
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	13.20	I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.03
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	10.12	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	9.14
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.74			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	[illegible]			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	12.89			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	15.81			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	4.06			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin_{c=40}^{c=20}}$	22.0			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin_{c=40}^{c=20}}$	11.0			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin_{c=40}^{c=20}}$	9.0			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin_{c=40}^{c=20}}$	12.0			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin_{c=40}^{c=20}}$	7.0			

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. [illegible]
Analytical No. [illegible]

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	[illegible]	I_{19}	$\frac{C27}{\Sigma nParaffin}_{c=40}^{c=20}$	[illegible]
I_2	$\frac{S}{N}$	[illegible]	I_{20}	$\frac{C30}{\Sigma nParaffin}_{c=40}^{c=20}$	[illegible]
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}$	18.01	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}_{c=40}^{c=20}$	[illegible]
I_4	$\frac{\Sigma CnH_{2n-8}}{\Sigma Aromatics}_{c=36}^{c=20}$	[illegible]	I_{22}	$\frac{[illegible]}{C_{30}+C_{31}+C_{32}}$	[illegible]
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}_{c=20}$	[illegible]	I_{23}	$\frac{[illegible]}{C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.60
I_6	$\frac{\Sigma CnH_{2n-12}}{\Sigma Aromatic}^{c=36}$	[illegible]	I_{24}	$\frac{CnH_{2n-6}}{CnH_{2n-18}}$	2.07
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	[illegible]			
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	[illegible]	I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.03
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.74	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	9.14
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	[illegible]			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	13.89			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	10.81			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	4.06			
I_{14}	$\frac{C20}{\Sigma nParaffin}_{c=40}^{c=20}$	22.0			
I_{15}	$\frac{C21}{\Sigma nParaffin}_{c=40}^{c=20}$	11.0			
I_{16}	$\frac{C24}{\Sigma nParaffin}_{c=40}^{c=20}$	9.0			
I_{17}	$\frac{C25}{\Sigma nParaffin}_{c=40}^{c=20}$	12.0			
I_{18}	$\frac{C26}{\Sigma nParaffin}_{c=40}^{c=20}$	7.0			

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 131553
Analytical No. 398578

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	[illegible].30
I_2	$\frac{S}{N}$	4.70
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.08
I_4	$\frac{\Sigma CnH_{2n-8}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	10.97
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	14.91
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	9.53
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.71
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.71
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.66
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	27.53
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	12.60
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	10.13
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	3.95
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	19.5
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	12.8
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.8
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.7
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.7

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.0
I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.2
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.2
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	5.1
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.70
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.08
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.10
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	9.13

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - Low Mix

Computer No. 321559
Analytical No. 578625

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.43
I_2	$\frac{S}{N}$	4.69
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	17.48
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	11.17
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	15.28
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	10.39
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	12.68
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	10.21
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	9.92
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	25.59
I_{11}	$\frac{\Sigma\ 3 \text{ Ring Naphthenes}}{\Sigma (P + N)}$	12.32
I_{12}	$\frac{\Sigma\ 4 \text{ Ring Naphthenes}}{\Sigma (P + N)}$	10.67
I_{13}	$\frac{\Sigma\ 5 \text{ Ring Naphthenes}}{\Sigma (P + N)}$	4.51
I_{14}	$\frac{C_{20}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	19.9
I_{15}	$\frac{C_{21}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	15.9
I_{16}	$\frac{C_{24}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	8.1
I_{17}	$\frac{C_{25}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	8.3
I_{18}	$\frac{C_{26}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	5.8

Index	Formula	Numerical Value
I_{19}	$\frac{C_{27}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	4.0
I_{20}	$\frac{C_{30}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	1.9
I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	2.8
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	6.4
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.83
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.76
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.16
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	7.25

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 310809
Analytical No. 525321

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.24
I_2	$\frac{S}{N}$	4.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	17.06
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}\Big\|_{c=36}^{c=20}$	8.42
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	14.12
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}\Big\|_{c=36}^{c=20}$	7.05
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	13.10
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.47
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	9.22
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	33.34
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma (P + N)}$	11.15
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma (P + N)}$	9.01
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma (P + N)}$	4.03
I_{14}	$\frac{C20}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	21.4
I_{15}	$\frac{C21}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	15.7
I_{16}	$\frac{C24}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	6.9
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	9.8
I_{18}	$\frac{C26}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	5.1
I_{19}	$\frac{C27}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	4.6
I_{20}	$\frac{C30}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	1.8
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}\Big\|_{c=40}^{c=20}$	3.7
I_{22}	$\frac{\Sigma C_{20}+C_{21}+C_{22}}{\Sigma C_{30}+C_{31}+C_{32}}$	5.6
I_{23}	$\frac{\Sigma C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.96
I_{24}	$\frac{\Sigma CnH_{2n-6}}{\Sigma CnH_{2n-18}}$	1.85
I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.01
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	6.92

Sample History

Oil Type - Crude
Origin - Grande Isle Mix
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 321801
Analytical No. 586003

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.605
I_2	$\frac{S}{N}$	4.07
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	17.45
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	11.00
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	15.75
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	10.14
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	13.78
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	10.07
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	7.38
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma (P + N)}$	26.34
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	12.72
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	11.00
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	4.42
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	21.6
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	10.8
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	8.9
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	11.8
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	6.5
I_{19}	$\frac{C_{27}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	3.6
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	2.7
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}{}^{c=20}_{c=40}}$	3.6
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	5.24
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.57
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.37
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.80
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	7.86

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 321809
Analytical No. 525406

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.33
I_2	$\frac{S}{N}$	4.1
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	17.73
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}_{c=36}^{c=20}$	10.17
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	13.83
I_6	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}{}_{c=36}^{c=20}$	8.03
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	13.55
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	10.79
I_9	$\frac{\Sigma CnH2n-18}{\Sigma Aromatics}$	9.82
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	31.39
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	11.62
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	9.65
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	4.11
I_{14}	$\frac{C20}{\Sigma nParaffin}{}_{c=40}^{c=20}$	21.4
I_{15}	$\frac{C21}{\Sigma nParaffin}{}_{c=40}^{c=20}$	12.2
I_{16}	$\frac{C24}{\Sigma nParaffin}{}_{c=40}^{c=20}$	8.4
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	9.8
I_{18}	$\frac{C26}{\Sigma nParaffin}{}_{c=40}^{c=20}$	6.0

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma nParaffin}{}_{c=40}^{c=20}$	4.4
I_{20}	$\frac{C30}{\Sigma nParaffin}{}_{c=40}^{c=20}$	2.9
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}_{c=40}^{c=20}$	3.8
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	5.4
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.65
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.81
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.04
I_{26}	$\frac{\Sigma-1\ Ring+2\ Ring\ Naphthenes}{\Sigma-5\ Ring+6\ Ring\ Naphthenes}$	7.10

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 310559
Analytical No. 578608

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.20	I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.60
I_2	$\frac{S}{N}$	3.80	I_{20}	$\frac{C30}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	2.30
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	17.20	I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	3.73
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	8.92	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	5.00
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	15.04	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.76
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	8.48			
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	12.59	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.96
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	9.39	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.07
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	8.79	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	9.75
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P + N)}$	31.91			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	12.11			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	8.98			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.35			
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	19.80			
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	13.30			
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.80			
I_{17}	$\frac{C25}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.80			
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.00			

Sample History

Oil Type - Crude
Origin - Grand Isle Mix
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 400000
Analytical No. 578635

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.07
I_2	$\frac{S}{N}$	1.2
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	14.93
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	8.04
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	14.62
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	7.51
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	14.20
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	9.50
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	7.65
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	40.66
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma (P + N)}$	13.13
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma (P + N)}$	8.28
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma (P + N)}$	3.45
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	10.20
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	9.50
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.80
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.20
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.40

Index	Formula	Numerical Value
I_{19}	$\frac{C_{27}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.90
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.10
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	5.60
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.10
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.16
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.96
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.59
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	5.90

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. 410559
Analytical No. 578606

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.22	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	7.10
I_2	$\frac{S}{N}$	1.30	I_{20}	$\frac{C30}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	4.10
I_3	$\frac{\Sigma \text{CnH}_{2n-6}}{\Sigma \text{Aromatic}}$	15.94	I_{21}	$\frac{C31}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	6.00
I_4	$\frac{\Sigma \text{CnH}_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	9.43	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	1.93
I_5	$\frac{\Sigma \text{CnH}_{2n-10}}{\Sigma \text{Aromatic}}$	14.22	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.16
I_6	$\frac{\Sigma \text{CnH}_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	8.87			
I_7	$\frac{\Sigma \text{CnH}_{2n-14}}{\Sigma \text{Aromatics}}$	15.12	I_{24}	$\frac{\Sigma\ \text{CnH}_{2n-6}}{\Sigma\ \text{CnH}_{2n-18}}$	1.61
I_8	$\frac{\Sigma \text{CnH}_{2n-16}}{\Sigma \text{Aromatics}}$	10.51	I_{25}	$\frac{\Sigma\ \text{CnH}_{2n-6}+\Sigma \text{CnH}_{2n-18}}{\text{CnH}_{2n-14}}$	1.72
I_9	$\frac{\Sigma \text{CnH}_{2n-18}}{\Sigma \text{Aromatics}}$	9.94	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	6.30
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	39.82			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	13.93			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	10.10			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	4.30			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	10.30			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	9.10			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	8.30			
I_{17}	$\frac{C25}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	8.40			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	7.10			

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 421559
Analytical No. 578623

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.08
I_2	$\frac{S}{N}$	1.2
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	14.62
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	8.05
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	14.61
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	7.65
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	15.50
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	10.33
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	8.47
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma (P + N)}$	40.71
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	12.87
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	8.90
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.60
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	9.90
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	10.60
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.10
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.10
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	6.80
I_{19}	$\frac{C_{27}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	6.90
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	4.10
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	5.60
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.11
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.22
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.73
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.49
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	6.00

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 421551
Analytical No. 598576

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.08	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.1
I_2	$\frac{S}{N}$	1.3	I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	15.84	I_{21}	$\frac{C31}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.8
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	9.07	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.16
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	13.91	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.12
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	7.50	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.95
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	15.16	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.57
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	10.27			
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.12	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	11.6
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	39.96			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	13.27			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	7.61			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	2.53			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.6			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	12.1			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.6			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.6			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.4			

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - Low Mix

Computer No. 421801
Analytical No. 586005

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.25
I_2	$\frac{S}{N}$	1.1
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	13.73
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	[illegible].39
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	15.50
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	7.06
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	16.71
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.98
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	6.17
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma (P + N)}$	39.59
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	13.46
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	7.97
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	2.57
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.8
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.9
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.8
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.8
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.2

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.8
I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.6
I_{21}	$\frac{C31}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.8
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.49
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.13
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.22
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.19
I_{26}	$\frac{\Sigma\text{-}1\ Ring+2\ Ring\ Naphthenes}{\Sigma\text{-}5\ Ring+6\ Ring\ Naphthenes}$	11.0

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 410801
Analytical No. 588718

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.29	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.1
I_2	$\frac{S}{N}$	1.37	I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.9
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	11.90	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.3
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	7.26	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.52
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	19.18	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.07
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	5.39			
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	14.84	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.53
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	11.48	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.33
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	7.80	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	15.0
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P+N)}$	42.70			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	14.10			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	8.61			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	2.14			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.1			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.7			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.8			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.6			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.5			

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 410809
Analytical No. 525319

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	.14	I_{19}	$\frac{C27}{\Sigma nParaffin_{c=40}^{c=20}}$	5.68
I_2	$\frac{S}{N}$	1.5	I_{20}	$\frac{C30}{\Sigma nParaffin_{c=40}^{c=20}}$	4.07
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	15.08	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	5.26
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}_{c=36}^{c=20}$	7.97	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.31
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	14.01	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.40
I_6	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}{}_{c=36}^{c=20}$	6.39	I_{24}	$\frac{\Sigma\ CnH2n-6}{\Sigma\ CnH_{2n-18}}$	1.94
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	15.59	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.47
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	10.17	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	19.9
I_9	$\frac{\Sigma CnH2n-18}{\Sigma Aromatics}$	7.78			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	44.19			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P+N)}$	13.57			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P+N)}$	8.18			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P+N)}$	1.59			
I_{14}	$\frac{C20}{\Sigma nParaffin_{c=40}^{c=20}}$	10.60			
I_{15}	$\frac{C21}{\Sigma nParaffin_{c=40}^{c=20}}$	10.32			
I_{16}	$\frac{C24}{\Sigma nParaffin_{c=40}^{c=20}}$	8.43			
I_{17}	$\frac{C25}{\Sigma nParaffin_{c=40}^{c=20}}$	8.33			
I_{18}	$\frac{C26}{\Sigma nParaffin_{c=40}^{c=20}}$	7.10			

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 421809
Analytical No. 525404

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.33	I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	7.1
I_2	$\frac{S}{N}$	0.77	I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	4.0
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	15.32	I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	5.1
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	9.06	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.48
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	14.21	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.05
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	7.47	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.83
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	16.00	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.48
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	10.53	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	6.30
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	8.34			
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P+N)}$	43.96			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P+N)}$	12.66			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P+N)}$	8.10			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P+N)}$	3.16			
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	10.30			
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	9.9			
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	9.1			
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	9.4			
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}_{c=40}^{c=20}}$	7.8			

Sample History

Oil Type - Crude
Origin - Nigerian
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 500000
Analytical No. 578633

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.30	I_{19}	$\frac{C27}{\Sigma nParaffin_{c=40}^{c=20}}$	5.40
I_2	$\frac{S}{N}$	2.5	I_{20}	$\frac{C_{30}}{\Sigma nParaffin_{c=40}^{c=20}}$	3.70
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	16.51	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=40}^{c=20}}$	3.60
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}_{c=36}^{c=20}$	8.67	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.62
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	14.10	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.45
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}_{c=36}^{c=20}$	7.87	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.77
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.63	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.05
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	9.21	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	9.12
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	9.37			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P+N)}$	49.54			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	8.25			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	5.80			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	2.32			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin_{c=40}^{c=20}}$	13.70			
I_{15}	$\frac{C21}{\Sigma nParaffin_{c=40}^{c=20}}$	11.40			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin_{c=40}^{c=20}}$	8.10			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin_{c=40}^{c=20}}$	7.30			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin_{c=40}^{c=20}}$	6.10			

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer .No. 521809
Analytical No. 525403

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.26	I_{19}	$\frac{C27}{\Sigma nParaffin_{c=20}^{c=40}}$	5.3
I_2	$\frac{S}{N}$	2.05	I_{20}	$\frac{C_{30}}{\Sigma nParaffin_{c=20}^{c=40}}$	3.5
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	17.40	I_{21}	$\frac{C_{31}}{\Sigma nParaffin_{c=20}^{c=40}}$	3.1
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}_{c=36}^{c=20}$	10.68	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.42
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	13.66	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.42
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}_{c=36}^{c=20}$	8.22			
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	14.49	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.79
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	10.69	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.87
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	9.72	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	7.70
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	48.23			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	7.84			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	6.03			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	2.63			
I_{14}	$\frac{C20}{\Sigma nParaffin_{c=40}^{c=20}}$	14.6			
I_{15}	$\frac{C21}{\Sigma nParaffin_{c=40}^{c=20}}$	12.5			
I_{16}	$\frac{C24}{\Sigma nParaffin_{c=40}^{c=20}}$	8.8			
I_{17}	$\frac{C25}{\Sigma nParaffin_{c=40}^{c=20}}$	8.2			
I_{18}	$\frac{C26}{\Sigma nParaffin_{c=40}^{c=20}}$	6.3			

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 510559
Analytical No. 578605

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.10	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.80
I_2	$\frac{S}{N}$	2.90	I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.40
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	16.94	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.30
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}^{c=20}_{c=36}$	10.83	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.34
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	15.10	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.36
I_6	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}{}^{c=20}_{c=36}$	10.20	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.61
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	13.21	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.09
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	10.24	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	9.21
I_9	$\frac{\Sigma CnH2n-18}{\Sigma Aromatics}$	10.51			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	46.53			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	8.53			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	6.35			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	2.53			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	14.50			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	12.10			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.80			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.10			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.50			

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 521559
Analytical No. 578622

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.2
I_2	$\frac{S}{N}$	2.8
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	16.92
I_4	$\frac{\Sigma CnH2n-6}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	9.52
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	14.70
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	8.77
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	12.77
I_8	$\frac{\Sigma CnH2n-16}{\Sigma \text{Aromatics}}$	10.49
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	11.08
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	47.06
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	8.40
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	6.22
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	2.40
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	13.30
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	11.80
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.60
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.20
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	6.50

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	5.70
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	3.70
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	3.29
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.87
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.33
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.53
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.17
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 510801
Analytical No. 588717

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.15	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	5.6
I_2	$\frac{S}{N}$	2.92	I_{20}	$\frac{C30}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	3.2
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	16.70	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	3.0
I_4	$\frac{\Sigma CnH2n-6}{\Sigma \text{Aromatics}}\,_{c=36}^{c=20}$	10.30	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.75
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	12.70	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.64
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}\,_{c=36}^{c=20}$	7.62	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.69
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	13.20	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.01
I_8	$\frac{\Sigma CnH2n-16}{\Sigma \text{Aromatics}}$	9.80	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	31.0
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	9.90			
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	48.64			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	8.76			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	5.96			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	0.00			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	14.7			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	12.9			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	8.9			
I_{17}	$\frac{C25}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	8.1			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}\,_{c=40}^{c=20}}$	6.3			

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 521551
Analytical No. 586030

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.19	I_{19}	$\frac{C_{27}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	5.5
I_2	$\frac{S}{N}$	2.8	I_{20}	$\frac{C_{30}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	3.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	17.61	I_{21}	$\frac{C_{31}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	2.9
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	9.89	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.6
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	13.92	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.39
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	8.01	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.03
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	13.02	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.01
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.49	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	14.70
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.65			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P + N)}$	48.27			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	8.81			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	5.95			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	1.92			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	14.6			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	12.5			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	8.9			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	7.9			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	6.4			

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - Low Mix

Computer No. 510809
Analytical No. 525318

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	0.24	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	5.7
I_2	$\frac{S}{N}$	2.2	I_{20}	$\frac{C30}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	3.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	17.25	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	3.0
I_4	$\frac{\Sigma CnH2n-6}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	10.76	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.26
I_5	$\frac{\Sigma CnH2n-10}{\Sigma \text{Aromatic}}$	14.32	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.31
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	9.40	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.61
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	13.40	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.08
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	10.35	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	5.92
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	10.68			
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P+N)}$	47.18			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P+N)}$	7.88			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P+N)}$	6.09			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P+N)}$	3.03			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	14.3			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	12.5			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	9.2			
I_{17}	$\frac{C25}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	8.3			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	6.4			

Sample History

Oil Type - Crude
Origin - Zuitina
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 600000
Analytical No. 577727

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	0.25
I_2	$\frac{S}{N}$	11.30	I_{20}	$\frac{C_{30}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	0.00
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	10.65	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	0.00
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	0.63	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	4.58	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	20.50
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	0.36	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	0.99
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	18.47	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.16
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	8.12	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	16.50
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	10.83			
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	51.18			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	9.35			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	5.17			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	1.95			
I_{14}	$\frac{C_{20}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	47.00			
I_{15}	$\frac{C_{21}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	28.20			
I_{16}	$\frac{C_{24}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	2.40			
I_{17}	$\frac{C_{25}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	1.00			
I_{18}	$\frac{C_{26}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	0.45			

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Note: $\frac{V}{Ni}$ index for No. 2 fuel oil was always ratios of very small values i.e., $\frac{< .01}{< .02}$ etc. The value of -10 was arbitrarily assigned to represent this condition

Computer No. 610551
Analytical No. 578078

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10	I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.3
I_2	$\frac{S}{N}$	15.0	I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.1
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	10.2	I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.1
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	.5	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	34.0
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	4.20	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	19.0
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	0.20			
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	20.0	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	0.8
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	8.40	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.2
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	12.10	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	17.0
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P+N)}$	62.0			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P+N)}$	4.0			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P+N)}$	3.3			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P+N)}$	0.20			
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	47.0			
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	28.2			
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	2.6			
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	1.2			
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.5			

Sample History

Oil Type -
Origin -
Weathering Time, days -
Weathering Temperature, °F -
Mixing Condition -

Computer No. 610559
Analytical No. 578610

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	0.30
I_2	$\frac{S}{N}$	14.80	I_{20}	$\frac{C30}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	0.13
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	10.21	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	0.13
I_4	$\frac{\Sigma CnH2n-6}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	0.47	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.42
I_5	$\frac{\Sigma CnH2n-10}{\Sigma \text{Aromatic}}$	4.21	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	18.9
I_6	$\frac{\Sigma CnH2n-10}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	0.14	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	0.84
I_7	$\frac{\Sigma CnH2n-14}{\Sigma \text{Aromatics}}$	19.51	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.15
I_8	$\frac{\Sigma CnH2n-16}{\Sigma \text{Aromatics}}$	8.38	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	
I_9	$\frac{\Sigma CnH2n-18}{\Sigma \text{Aromatics}}$	12.09			
I_{10}	$\frac{\Sigma \text{nParaffins}}{\Sigma\ (P + N)}$	62.20			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	3.90			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	3.30			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	0.20			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	46.60			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	28.20			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	2.60			
I_{17}	$\frac{C_{25}}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	1.13			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}}{}^{c=20}_{c=40}$	0.52			

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 621559
Analytical No. 578628

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10
I_2	$\frac{S}{N}$	14.0
I_3	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatic}}$	10.44
I_4	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatics}}\Big\|_{c=36}^{c=20}$	.53
I_5	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}$	4132
I_6	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}\Big\|_{c=36}^{c=20}$	.16
I_7	$\frac{\Sigma C_nH_{2n-14}}{\Sigma \text{Aromatics}}$	20.03
I_8	$\frac{\Sigma C_nH_{2n-16}}{\Sigma \text{Aromatics}}$	8.39
I_9	$\frac{\Sigma C_nH_{2n-18}}{\Sigma \text{Aromatics}}$	13.61
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	60.70
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	4.00
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	3.10
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	0.00
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	48.50
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	27.20
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	2.30
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	0.80
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	0.22

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	0.11
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	0.00
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}\Big\|_{c=40}^{c=20}$	0.00
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	26.70
I_{24}	$\frac{\Sigma\ C_nH_{2n-6}}{\Sigma\ C_nH_{2n-18}}$	0.77
I_{25}	$\frac{\Sigma\ C_nH_{2n-6}+\Sigma C_nH_{2n-18}}{C_nH_{2n-14}}$	1.21
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 61[illegible]
Analytical No. 525324

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10	I_{19}	$\frac{C27}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	0.00
I_2	$\frac{S}{N}$	13.50	I_{20}	$\frac{C_{30}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	0.00
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	11.60	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	0.00
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	0.72	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	4.82	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	36.70
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	0.38			
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	20.48	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.22
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	7.47	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.03
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	9.54	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	60.70			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	2.50			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	3.80			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	0.00			
I_{14}	$\frac{C20}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	49.80			
I_{15}	$\frac{C21}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	28.40			
I_{16}	$\frac{C24}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	1.90			
I_{17}	$\frac{C25}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	0.60			
I_{18}	$\frac{C26}{\Sigma \text{nParaffin}}{}_{c=40}^{c=20}$	0.00			

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 621801
Analytical No. 525409

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.0
I_2	$\frac{S}{N}$	28.5	I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.0
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	10.99	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.0
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}^{c=20}_{c=36}$	0.88	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	4.36	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	30.5
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	0.32			
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	22.35	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	0.83
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	9.15	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.10
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	13.31	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthanes}}$	
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	63.6			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	3.1			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	2.4			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	0.0			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	51.8			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	26.8			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	2.1			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.7			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.2			

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 621809
Analytical No. 598591

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10	I_{19}	$\left.\frac{C27}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	0.0
I_2	$\frac{S}{N}$	31.6	I_{20}	$\left.\frac{C30}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	0.0
I_3	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatic}}$	14.11	I_{21}	$\left.\frac{C_{31}}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	0.0
I_4	$\left.\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatics}}\right\|_{c=36}^{c=20}$	0.62	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	10/10
I_5	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}$	5.69	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	14.3
I_6	$\left.\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}\right\|_{c=36}^{c=20}$	0.28	I_{24}	$\frac{\Sigma\ C_nH_{2n-6}}{\Sigma\ C_nH_{2n-18}}$	1.92
I_7	$\frac{\Sigma C_nH_{2n-14}}{\Sigma \text{Aromatics}}$	18.38	I_{25}	$\frac{\Sigma\ C_nH_{2n-6}+\Sigma C_nH_{2n-18}}{C_nH_{2n-14}}$	1.17
I_8	$\frac{\Sigma C_nH_{2n-16}}{\Sigma \text{Aromatics}}$	6.00	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	
I_9	$\frac{\Sigma C_nH_{2n-18}}{\Sigma \text{Aromatics}}$	7.32			
I_{10}	$\frac{\Sigma \text{nParaffins}}{\Sigma\ (P + N)}$	51.1			
I_{11}	$\frac{\Sigma\ 3 \text{ Ring Naphthenes}}{\Sigma(P + N)}$	9.25			
I_{12}	$\frac{\Sigma\ 4 \text{ Ring Naphthenes}}{\Sigma(P + N)}$	3.65			
I_{13}	$\frac{\Sigma\ 5 \text{ Ring Naphthenes}}{\Sigma(P + N)}$	0.33			
I_{14}	$\left.\frac{C20}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	45.3			
I_{15}	$\left.\frac{C21}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	27.5			
I_{16}	$\left.\frac{C24}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	4.1			
I_{17}	$\left.\frac{C25}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	2.0			
I_{18}	$\left.\frac{C26}{\Sigma \text{nParaffin}}\right\|_{c=40}^{c=20}$	0.0			

Sample History

Oil Type - NO. 2 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 621801
Analytical No. 586050

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	<1.0
I_2	$\frac{S}{N}$	5.0
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	13.07
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	1.00
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	1.55
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	.31
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	21.92
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	6.01
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	6.08
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	60.70
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	2.50
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	3.80
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	0.00
I_{14}	$\frac{C_{20}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	30.00
I_{15}	$\frac{C_{21}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	28.00
I_{16}	$\frac{C_{24}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	1.90
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.60
I_{18}	$\frac{C_{26}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.20

Index	Formula	Numerical Value
I_{19}	$\frac{C_{27}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0.10
I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	0
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	10/10
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{29}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	27.00
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	1.95
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+CnH_{2n-18}}{CnH_{2n-14}}$	0.91
I_{26}	$\frac{\Sigma\text{-}1\ Ring+2\ Ring\ Naphthenes}{\Sigma\text{-}5\ Ring+6\ Ring\ Naphthenes}$	

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, Days - 21
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 610801
Analytical No. 588723

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	-10
I_2	$\frac{S}{N}$	13.5
I_3	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatic}}$	10.62
I_4	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	0.69
I_5	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}$	4.54
I_6	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	0.22
I_7	$\frac{\Sigma C_nH_{2n-14}}{\Sigma \text{Aromatics}}$	22.80
I_8	$\frac{\Sigma C_nH_{2n-16}}{\Sigma \text{Aromatics}}$	7.12
I_9	$\frac{\Sigma C_nH_{2n-18}}{\Sigma \text{Aromatics}}$	8.20
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P + N)}$	51.40
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	9.40
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	3.60
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	0.00
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	48.0
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	28.4
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	2.1
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.8
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.0

Index	Formula	Numerical Value
I_{19}	$\frac{C_{27}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.0
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.0
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	0.0
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	31.8
I_{24}	$\frac{\Sigma\ C_nH_{2n-6}}{\Sigma\ C_nH_{2n-18}}$	1.29
I_{25}	$\frac{\Sigma\ C_nH_{2n-6}+\Sigma C_nH_{2n-18}}{C_nH_{2n-14}}$	0.83
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	

Sample History

Oil Type - No. 2 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 700000
Analytical No. 578650

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	5.3
I_2	$\frac{S}{N}$	3.6
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	19.67
I_4	$\left.\frac{\Sigma CnH2n-6}{\Sigma \text{Aromatics}}\right\|^{c=20}_{c=36}$	8.31
I_5	$\frac{\Sigma CnH2n-10}{\Sigma \text{Aromatic}}$	15.03
I_6	$\left.\frac{\Sigma CnH2n-10}{\Sigma \text{Aromatic}}\right\|^{c=20}_{c=36}$	7.45
I_7	$\frac{\Sigma CnH2n-14}{\Sigma \text{Aromatics}}$	11.03
I_8	$\frac{\Sigma CnH2n-16}{\Sigma \text{Aromatics}}$	7.88
I_9	$\frac{\Sigma CnH2n-18}{\Sigma \text{Aromatics}}$	5.73
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P + N)}$	34.93
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	11.16
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	5.46
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	1.49
I_{14}	$\left.\frac{C20}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	20.3
I_{15}	$\left.\frac{C21}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	11.8
I_{16}	$\left.\frac{C24}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	7.5
I_{17}	$\left.\frac{C_{25}}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	7.5
I_{18}	$\left.\frac{C26}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	6.9
I_{19}	$\left.\frac{C27}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	6.8
I_{20}	$\left.\frac{C30}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	4.3
I_{21}	$\left.\frac{C_{31}}{\Sigma n\text{Paraffin}}\right\|^{c=20}_{c=40}$	3.1
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	4.54
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.52
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	3.46
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.31
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. 710559
Analytical No. 525301

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	6.8	I_{19}	$\frac{C_{27}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.7
I_2	$\frac{S}{N}$	3.8	I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.98	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.5
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	9.11	I_{22}	$\frac{\Sigma C_{20}+C_{21}+C_{22}}{\Sigma C_{30}+C_{31}+C_{32}}$	3.53
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	15.66	I_{23}	$\frac{\Sigma C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.68
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	8.05	I_{24}	$\frac{\Sigma CnH_{2n-6}}{\Sigma CnH_{2n-18}}$	3.25
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	11.93	I_{25}	$\frac{\Sigma CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.09
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	8.76	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	29.0
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	5.84			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma (P + N)}$	35.11			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	11.45			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	5.72			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	1.50			
I_{14}	$\frac{C_{20}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	19.3			
I_{15}	$\frac{C_{21}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	12.0			
I_{16}	$\frac{C_{24}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.0			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.0			
I_{18}	$\frac{C_{26}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.5			

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 721551
Analytical No. 598582

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	5.7
I_2	$\frac{S}{N}$	3.5
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	24.07
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	11.98
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	19.65
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	11.68
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	7.75
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	4.85
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	3.16
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	35.90
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	10.97
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	5.61
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	1.45
I_{14}	$\frac{C20}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	16.9
I_{15}	$\frac{C21}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	10.7
I_{16}	$\frac{C24}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.6
I_{17}	$\frac{C25}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.3
I_{18}	$\frac{C26}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.8

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.2
I_{20}	$\frac{C_{32}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.7
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.1
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.28
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.45
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	7.64
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	3.51
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	31.4

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - Low Mix

Computer No. 710809
Analytical No. 525325

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.2	I_{19}	$\frac{C_{27}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	6.1
I_2	$\frac{S}{N}$	3.3	I_{20}	$\frac{C_{30}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	3.7
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	18.76	I_{21}	$\frac{C_{31}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	5.3
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	9.75	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.83
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	16.24	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.66
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	8.95	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.60
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	11.97			
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	9.31	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.17
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	7.23	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	29.1
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma\ (P + N)}$	34.35			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P + N)}$	11.05			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P + N)}$	6.31			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P + N)}$	2.81			
I_{14}	$\frac{C_{20}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	17.4			
I_{15}	$\frac{C_{21}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	11.4			
I_{16}	$\frac{C_{24}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	6.6			
I_{17}	$\frac{C_{25}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	7.1			
I_{18}	$\frac{C_{26}}{\Sigma \text{nParaffin}_{c=40}^{c=20}}$	6.1			

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 721801
Analytical No. 586049

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	5.42	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.6
I_2	$\frac{S}{N}$	2.67	I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.9
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.24	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.6
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	10.05	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.15
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	17.36	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.62
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	10.09	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	3.18
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.73	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.89
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.09	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	31.7
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	5.74			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P+N)}$	33.57			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	12.13			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	6.76			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	1.43			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	18.6			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	11.5			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.1			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.0			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.5			

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 721809
Analytical No. 523410

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	5.0
I_2	$\frac{S}{N}$	3.6
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	19.13
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	8.89
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	16.24
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	7.79
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.67
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	9.26
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	5.87
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	35.92
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	10.80
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	5.79
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	2.17
I_{14}	$\frac{C_{20}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	20.1
I_{15}	$\frac{C_{21}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	11.2
I_{16}	$\frac{C_{24}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	6.8
I_{17}	$\frac{C_{25}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	7.6
I_{18}	$\frac{C_{26}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	6.3

Index	Formula	Numerical Value
I_{19}	$\frac{C_{27}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	5.7
I_{20}	$\frac{C_{30}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	4.7
I_{21}	$\frac{C_{31}}{\Sigma nParaffin{}^{c=20}_{c=40}}$	5.0
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.13
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.69
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	3.25
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.97
I_{26}	$\frac{\Sigma-1\ Ring+2\ Ring\ Naphthenes}{\Sigma-5\ Ring+6\ Ring\ Naphthenes}$	13.40

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 710801
Analytical No. 588724

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	5.60
I_2	$\frac{S}{N}$	3.23
I_3	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatic}}$	18.30
I_4	$\frac{\Sigma C_nH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	9.12
I_5	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}$	16.41
I_6	$\frac{\Sigma C_nH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	8.27
I_7	$\frac{\Sigma C_nH_{2n-14}}{\Sigma \text{Aromatics}}$	12.90
I_8	$\frac{\Sigma C_nH_{2n-16}}{\Sigma \text{Aromatics}}$	9.26
I_9	$\frac{\Sigma C_nH_{2n-18}}{\Sigma \text{Aromatics}}$	5.98
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma (P + N)}$	37.25
I_{11}	$\frac{\Sigma\ 3 \text{ Ring Naphthenes}}{\Sigma (P + N)}$	11.40
I_{12}	$\frac{\Sigma\ 4 \text{ Ring Naphthenes}}{\Sigma (P + N)}$	6.29
I_{13}	$\frac{\Sigma\ 5 \text{ Ring Naphthenes}}{\Sigma (P + N)}$	2.10
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	18.2
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	12.7
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.8
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	7.3
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	5.8

Index	Formula	Numerical Value
I_{19}	$\frac{C_{27}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.00
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	3.9
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.8
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	3.16
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.65
I_{24}	$\frac{\Sigma\ C_nH_{2n-6}}{\Sigma\ C_nH_{2n-18}}$	3.06
I_{25}	$\frac{\Sigma\ C_nH_{2n-6}+\Sigma C_nH_{2n-18}}{C_nH_{2n-14}}$	1.88
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	16.70

Sample History

Oil Type - No. 4 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 800000
Analytical No. 578639

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.3	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.10
I_2	$\frac{S}{N}$	3.9	I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.70
I_3	$\frac{\Sigma CnH2n-6}{\Sigma Aromatic}$	17.90	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	1.00
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}^{c=20}_{c=36}$	9.79	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	5.30
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	16.06	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.00
I_6	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}{}^{c=20}_{c=36}$	9.23	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.31
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	12.67	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.03
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	10.09	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	8.05
I_9	$\frac{\Sigma CnH2n-18}{\Sigma Aromatics}$	7.73			
I_{10}	$\frac{\Sigma n Paraffins}{\Sigma\ (P + N)}$	28.38			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	12.93			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	6.83			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	3.57			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	12.00			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.50			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.40			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.90			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.20			

Sample History

Oil Type - No. 5 Fuel Oil
Origin -
Weathering Time, days - Unweathered
Weathering Temperature, °F -
Mixing Condition -

Computer No. 810559
Analytical No. 578609

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.70	I_{19}	$\frac{C27}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	7.20
I_2	$\frac{S}{N}$	4.20	I_{20}	$\frac{C30}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	3.87
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.11	I_{21}	$\frac{C_{31}}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	4.68
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}\,{}^{c=20}_{c=36}$	10.50	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.67
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	16.23	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.13
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}\,{}^{c=20}_{c=36}$	9.78	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.23
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.90	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.04
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	10.36	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	8.20
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.14			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	33.53			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	12.19			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	7.92			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	3.43			
I_{14}	$\frac{C20}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	11.20			
I_{15}	$\frac{C21}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	10.00			
I_{16}	$\frac{C24}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	8.40			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	9.10			
I_{18}	$\frac{C26}{\Sigma nParaffin\,{}^{c=20}_{c=40}}$	7.50			

Sample History

Oil Type - No. 5 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 810551
Analytical No. 235620

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.0
I_2	$\frac{S}{N}$	4.2
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.0
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}^{c=20}_{c=36}$	11.0
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	16.0
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	10.0
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	13.0
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	10.3
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	8.1
I_{10}	$\frac{\Sigma nParaffins}{\Sigma (P + N)}$	33.5
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	12.0
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	8.0
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	3.4
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	11.2
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.0
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.0
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.2
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.5
I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.3
I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.9
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.7
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.70
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.10
I_{24}	$\frac{\Sigma\ Cnh_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.30
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.00
I_{26}	$\frac{\Sigma-1\ Ring+2\ Ring\ Naphthenes}{\Sigma-5\ Ring+6\ Ring\ Naphthenes}$	8.0

Sample History

Oil Type -
Origin -
Weathering Time, days -
Weathering Temperature, °F -
Mixing Condition -

Computer No. 821559
Analytical No. 578626

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	
I_2	$\frac{S}{N}$	
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.07
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	10.45
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	16.45
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	9.87
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	13.12
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	10.56
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	7.56
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	31.18
I_{11}	$\frac{\Sigma\ 3\ Ring\ Naphthenes}{\Sigma(P + N)}$	12.58
I_{12}	$\frac{\Sigma\ 4\ Ring\ Naphthenes}{\Sigma(P + N)}$	8.38
I_{13}	$\frac{\Sigma\ 5\ Ring\ Naphthenes}{\Sigma(P + N)}$	3.56
I_{14}	$\frac{C_{20}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.90
I_{15}	$\frac{C_{21}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.20
I_{16}	$\frac{C_{24}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.80
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.30
I_{18}	$\frac{C_{26}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.80
I_{19}	$\frac{C_{27}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.10
I_{20}	$\frac{C_{30}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	3.90
I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.00
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.49
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.19
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.39
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.95
I_{26}	$\frac{\Sigma\text{-}1\ Ring+2\ Ring\ Naphthenes}{\Sigma\text{-}5\ Ring+6\ Ring\ Naphthenes}$	7.87

Sample History

Oil Type -No. 5 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - High Mix

Computer No. 821551
Analytical No. 598579

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	8.4
I_2	$\frac{S}{N}$	4.4
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	18.05
I_4	$\frac{\Sigma CnH2n-6}{\Sigma \text{Aromatics}}{}^{c=20}_{c=36}$	10.39
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	16.97
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}^{c=20}_{c=36}$	10.45
I_7	$\frac{\Sigma CnH2n-14}{\Sigma \text{Aromatics}}$	13.09
I_8	$\frac{\Sigma CnH2n-16}{\Sigma \text{Aromatics}}$	9.47
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	5.81
I_{10}	$\frac{\Sigma n\text{Paraffins}}{\Sigma\ (P + N)}$	30.43
I_{11}	$\frac{\Sigma\ 3\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	12.47
I_{12}	$\frac{\Sigma\ 4\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	7.54
I_{13}	$\frac{\Sigma\ 5\ \text{Ring Naphthenes}}{\Sigma(P + N)}$	2.82
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	11.3
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	9.7
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.8
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	8.3
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	7.1

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	6.5
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	4.9
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}^{c=20}_{c=40}$	4.3
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.56
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.19
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	3.10
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma Cnh_{2n-18}}{CnH_{2n-14}}$	1.82
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	12.70

Sample History

Oil Type -No. 5 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 55
Mixing Condition - Low Mix

Computer No. 810801
Analytical No. 583721

Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.8
I_2	$\frac{S}{N}$	3.9
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatic}}$	18.53
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma \text{Aromatics}}{}_{c=36}^{c=20}$	11.44
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}$	16.17
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma \text{Aromatic}}{}_{c=36}^{c=20}$	10.37
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma \text{Aromatics}}$	12.94
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma \text{Aromatics}}$	10.40
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma \text{Aromatics}}$	7.64
I_{10}	$\frac{\Sigma_n \text{Paraffins}}{\Sigma (P + N)}$	32.24
I_{11}	$\frac{\Sigma \text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	13.08
I_{12}	$\frac{\Sigma \text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	7.43
I_{13}	$\frac{\Sigma \text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	1.12
I_{14}	$\frac{C_{20}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	11.9
I_{15}	$\frac{C_{21}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	10.1
I_{16}	$\frac{C_{24}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	8.6
I_{17}	$\frac{C_{25}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	9.1
I_{18}	$\frac{C_{26}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.8

Index	Formula	Numerical Value
I_{19}	$\frac{C27}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	6.5
I_{20}	$\frac{C_{30}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	3.6
I_{21}	$\frac{C_{31}}{\Sigma n\text{Paraffin}}{}_{c=40}^{c=20}$	4.7
I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.75
I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.18
I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.42
I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.48
I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	40.8

Sample History

Oil Type - No. 5 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 810809
Analytical No. 525320

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.9	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.80
I_2	$\frac{S}{N}$	4.3	I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.20
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.25	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	4.50
I_4	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatics}{}^{c=20}_{c=36}$	10.95	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.69
I_5	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}$	16.71	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.20
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	7.65	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	2.35
I_7	$\frac{\Sigma CnH_{2n-14}}{\Sigma Aromatics}$	12.60	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	2.07
I_8	$\frac{\Sigma CnH_{2n-16}}{\Sigma Aromatics}$	10.01	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	10.30
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	7.79			
I_{10}	$\frac{\Sigma_n Paraffins}{\Sigma\ (P + N)}$	31.17			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P + N)}$	11.95			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P + N)}$	7.22			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P + N)}$	2.95			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	11.70			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.80			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.50			
I_{17}	$\frac{C25}{\Sigma nParaffin}{}^{c=20}_{c=40}$	10.10			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.90			

Sample History

Oil Type - No. 5 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - High Mix

Computer No. 821801
Analytical No. 586002

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	3.12	I_{19}	$\frac{C27}{\Sigma nParaffin}{}^{c=20}_{c=40}$	6.50
I_2	$\frac{S}{N}$	3.61	I_{20}	$\frac{C30}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.00
I_3	$\frac{\Sigma CnH_{2n-6}}{\Sigma Aromatic}$	18.15	I_{21}	$\frac{C_{31}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	5.00
I_4	$\frac{\Sigma CnH2n-6}{\Sigma Aromatics}{}^{c=20}_{c=36}$	10.70	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.29
I_5	$\frac{\Sigma CnH2n-10}{\Sigma Aromatic}$	18.26	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.24
I_6	$\frac{\Sigma CnH_{2n-10}}{\Sigma Aromatic}{}^{c=20}_{c=36}$	11.51	I_{24}	$\frac{\Sigma\ CnH_{2n-6}}{\Sigma\ CnH_{2n-18}}$	3.42
I_7	$\frac{\Sigma CnH2n-14}{\Sigma Aromatics}$	12.86	I_{25}	$\frac{\Sigma\ CnH_{2n-6}+\Sigma CnH_{2n-18}}{CnH_{2n-14}}$	1.83
I_8	$\frac{\Sigma CnH2n-16}{\Sigma Aromatics}$	9.08	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	50.5
I_9	$\frac{\Sigma CnH_{2n-18}}{\Sigma Aromatics}$	5.31			
I_{10}	$\frac{\Sigma nParaffins}{\Sigma\ (P+N)}$	30.41			
I_{11}	$\frac{\Sigma\text{ 3 Ring Naphthenes}}{\Sigma(P+N)}$	13.03			
I_{12}	$\frac{\Sigma\text{ 4 Ring Naphthenes}}{\Sigma(P+N)}$	7.74			
I_{13}	$\frac{\Sigma\text{ 5 Ring Naphthenes}}{\Sigma(P+N)}$	0.93			
I_{14}	$\frac{C20}{\Sigma nParaffin}{}^{c=20}_{c=40}$	11.40			
I_{15}	$\frac{C21}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.90			
I_{16}	$\frac{C24}{\Sigma nParaffin}{}^{c=20}_{c=40}$	8.50			
I_{17}	$\frac{C_{25}}{\Sigma nParaffin}{}^{c=20}_{c=40}$	9.10			
I_{18}	$\frac{C26}{\Sigma nParaffin}{}^{c=20}_{c=40}$	7.20			

Sample History

Oil Type - No. 5 Fuel Oil
Origin -
Weathering Time, days - 10
Weathering Temperature, °F - 80
Mixing Condition - Low Mix

Computer No. 821809
Analytical No. 525407

Index	Formula	Numerical Value	Index	Formula	Numerical Value
I_1	$\frac{V}{Ni}$	7.82	I_{19}	$\frac{C27}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	5.80
I_2	$\frac{S}{N}$	3.89	I_{20}	$\frac{C30}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	4.20
I_3	$\frac{\Sigma\text{CnH}_{2n-6}}{\Sigma\text{Aromatic}}$	19.97	I_{21}	$\frac{C_{31}}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	4.50
I_4	$\frac{\Sigma\text{CnH}_{2n-6}}{\Sigma\text{Aromatics}}{}_{c=36}^{c=20}$	9.55	I_{22}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}}{\Sigma\ C_{30}+C_{31}+C_{32}}$	2.69
I_5	$\frac{\Sigma\text{CnH}_{2n-10}}{\Sigma\text{Aromatic}}$	16.24	I_{23}	$\frac{\Sigma\ C_{20}+C_{21}+C_{22}+C_{30}+C_{31}+C_{32}}{\Sigma\ C_{24}+C_{25}+C_{26}+C_{27}+C_{28}}$	1.20
I_6	$\frac{\Sigma\text{CnH}_{2n-10}}{\Sigma\text{Aromatic}}{}_{c=36}^{c=20}$	9.03			
I_7	$\frac{\Sigma\text{CnH}_{2n-14}}{\Sigma\text{Aromatics}}$	12.62	I_{24}	$\frac{\Sigma\ \text{CnH}_{2n-6}}{\Sigma\ \text{CnH}_{2n-18}}$	2.93
I_8	$\frac{\Sigma\text{CnH}_{2n-16}}{\Sigma\text{Aromatics}}$	9.72	I_{25}	$\frac{\Sigma\ \text{CnH}_{2n-6}+\Sigma\text{CnH}_{2n-18}}{\text{CnH}_{2n-14}}$	2.12
I_9	$\frac{\Sigma\text{CnH}_{2n-18}}{\Sigma\text{Aromatics}}$	6.82	I_{26}	$\frac{\Sigma\text{-1 Ring+2 Ring Naphthenes}}{\Sigma\text{-5 Ring+6 Ring Naphthenes}}$	8.64
I_{10}	$\frac{\Sigma_n\text{Paraffins}}{\Sigma\ (P+N)}$	33.12			
I_{11}	$\frac{\Sigma\ \text{3 Ring Naphthenes}}{\Sigma(P+N)}$	11.79			
I_{12}	$\frac{\Sigma\ \text{4 Ring Naphthenes}}{\Sigma(P+N)}$	7.48			
I_{13}	$\frac{\Sigma\ \text{5 Ring Naphthenes}}{\Sigma(P+N)}$	3.23			
I_{14}	$\frac{C20}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	11.70			
I_{15}	$\frac{C21}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	9.80			
I_{16}	$\frac{C24}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	8.50			
I_{17}	$\frac{C25}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	10.10			
I_{18}	$\frac{C26}{\Sigma\text{nParaffin}}{}_{c=40}^{c=20}$	6.90			

Sample History

Oil Type - No. 5 Fuel Oil
Origin -
Weathering Time, days - 21
Weathering Temperature, °F - 80
Mixing Condition - High Mix

APPENDIX C

GAS CHROMATOGRAPHIC DISTILLATION DATA

No. 5 Fuel Oil

% Boiled Off	Unweathered	10 Days at 80°F	21 Days at 80°F
Initial B.P.	Below 250	550	450
1	285	582	565
2	325	600	585
3	347	612	600
5	380	627	615
7	400	640	630
10	425	657	648
15	465	682	673
20	500	705	696
25	537	725	717
30	580	744	740
35	623	763	760
40	661	782	782
45	695	801	802
50	727	820	823
55	757	838	842
60	786	860	862
65	815	882	885
70	847	907	910
75	880	935	935
80	915	965	965
85	958	1005	1003
90	1013	1007	1070

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GAS CHROMATOGRAPHIC DISTILLATION DATA

No. 4 Fuel Oil

% Boiled Off	Unweathered	Temperature, °F 10 Days at 80°F	21 Days at 80°F
Initial B.P.	Below 250	325	500
1	315	495	522
2	355	528	532
3	380	542	540
5	412	550	552
7	435	562	563
10	560	575	575
15	491	595	592
20	515	615	608
25	535	636	623
30	553	659	641
35	572	684	664
40	590	711	690
45	608	742	720
50	631	771	752
55	660	798	783
60	698	823	813
65	744	847	840
70	790	873	867
75	832	900	895
80	872	932	925
85	915	968	960
90	965	1018	1005
95			1056

GAS CHROMATOGRAPHIC DISTILLATION DATA

Tia Juana Medium Crude

	Temperature, °F	
% Boiled Off	Unweathered	21 Days at 55°F
Initial B.P.	Too Light to Measure	430
1		465
2		485
3		498
5		520
7		540
10	250	563
15	345	598
20	415	631
25	475	665
30	532	700
35	585	735
40	637	771
45	690	808
50	743	845
55	798	882
60	855	922
65	917	964
70	983	1011
75	1060	1070

APPENDIX D

GENERAL STATISTICS

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                         MULTIPLE REGRESSION ANALYSIS
                          PROGRAM REG

  LIEBERMAN - SOURCE 1 - 15MAY72
     NUMBER VARIABLES     =   26

     NUMBER OBSERVATIONS =    11

     GENERAL STATISTICS

     VARIABLE                                  STANDARD             RANGE
      NUMBER      SUM          AVERAGE        DEVIATION       MAX              MIN

         1    0.8569E 02   0.779090E 01   0.450160E 00   0.910000E 01   0.740000E 01
         2    0.6719E 02   0.610909E 01   0.384836E 00   0.670000E 01   0.540000E 01
         3    0.2332E 03   0.212072E 02   0.321024E 00   0.217600E 02   0.207900E 02
         4    0.1357E 03   0.123399E 02   0.134758E 01   0.146300E 02   0.103100E 02
         5    0.1379E 03   0.125372E 02   0.504850E 00   0.131800E 02   0.113100E 02
         6    0.9391E 02   0.853818E 01   0.875565E 00   0.958000E 01   0.682000E 01
         7    0.1342E 03   0.122081E 02   0.637164E 00   0.132400E 02   0.114300E 02
         8    0.9360E 02   0.850999E 01   0.454132E 00   0.922000E 01   0.790000E 01
         9    0.9712E 02   0.837545E 01   0.654430E 00   0.904000E 01   0.670000E 01
        10    0.3754E 03   0.341345E 02   0.217177E 01   0.394800E 02   0.311800E 02
        11    0.1258E 03   0.114372E 02   0.449446E 00   0.120000E 02   0.104600E 02
        12    0.7397E 02   0.672545E 01   0.309144E 00   0.739000E 01   0.611000E 01
        13    0.3055E 02   0.277818E 01   0.525855E 00   0.362000E 01   0.176000E 01
        14    0.1635E 03   0.148727E 02   0.623904E 00   0.161000E 02   0.142000E 02
        15    0.1287E 03   0.117090E 02   0.435795E 00   0.127000E 02   0.111000E 02
        16    0.9069E 02   0.824545E 01   0.342089E 00   0.880000E 01   0.760000E 01
        17    0.9009E 02   0.819090E 01   0.360440E 00   0.870000E 01   0.760000E 01
        18    0.7059E 02   0.641818E 01   0.244273E 00   0.670000E 01   0.600000E 01
        19    0.6319E 02   0.574545E 01   0.375048E 00   0.620000E 01   0.480000E 01
        20    0.3849E 02   0.349999E 01   0.388470E 00   0.430000E 01   0.290000E 01
        21    0.4179E 02   0.379999E 01   0.310424E 00   0.460000E 01   0.340000E 01
        22    0.4053E 02   0.368545E 01   0.241712E 00   0.412000E 01   0.342000E 01
        23    0.1570E 02   0.142818E 01   0.521916E-01   0.155000E 01   0.136000E 01
        24    0.2802E 02   0.254818E 01   0.236328E 00   0.313000E 01   0.230000E 01
        25    0.2674E 02   0.243181E 01   0.160670E 00   0.269000E 01   0.210000E 01
        26    0.1278E 03   0.116209E 02   0.536911E 01   0.249000E 02   0.655000E 01
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                                  MULTIPLE REGRESSION ANALYSIS
                                     PROGRAM REG

LIEBERMAN - SOURCE 2 - 15MAY72
     NUMBER VARIABLES      =    26

     NUMBER OBSERVATIONS =      5

     GENERAL STATISTICS

     VARIABLE                                        STANDARD                    RANGE
      NUMBER       SUM           AVERAGE             DEVIATION          MAX                  MIN

        1     0.3170E 02     0.633999E 01     0.106508E 01     0.730000E 01     0.460000E 01
        2     0.3069E 02     0.613999E 01     0.392937E 00     0.650000E 01     0.540000E 01
        3     0.9669E 02     0.193399E 02     0.463594E 00     0.200600E 02     0.188600E 02
        4     0.6166E 02     0.123339E 02     0.119760E 01     0.145000E 02     0.111700E 02
        5     0.7094E 02     0.141899E 02     0.762679E 00     0.156400E 02     0.133800E 02
        6     0.5150E 02     0.103019E 02     0.114093E 01     0.125000E 02     0.941000E 01
        7     0.6268E 02     0.125379E 02     0.419924E 00     0.132800E 02     0.121000E 02
        8     0.4460E 02     0.892200E 01     0.149586E 00     0.914000E 01     0.868000E 01
        9     0.4311E 02     0.862399E 01     0.142453E 01     0.962000E 01     0.582000E 01
       10     0.9611E 02     0.192239E 02     0.258053E 01     0.238200E 02     0.166000E 02
       11     0.8149E 02     0.162979E 02     0.585812E 00     0.167300E 02     0.151400E 02
       12     0.5017E 02     0.100359E 02     0.714215E 00     0.111800E 02     0.917000E 01
       13     0.1993E 02     0.398799E 01     0.515495E 00     0.450000E 01     0.317000E 01
       14     0.5930E 02     0.116600E 02     0.652993E 00     0.125000E 02     0.110000E 02
       15     0.4859E 02     0.971999E 01     0.702566E 00     0.105000E 02     0.880000E 01
       16     0.4009E 02     0.801999E 01     0.584465E 00     0.890000E 01     0.730000E 01
       17     0.4420E 02     0.884000E 01     0.454312E 00     0.950000E 01     0.810000E 01
       18     0.3160E 02     0.631999E 01     0.570613E 00     0.710000E 01     0.550000E 01
       19     0.3119E 02     0.623999E 01     0.665131E 00     0.700000E 01     0.520000E 01
       20     0.1617E 02     0.323400E 01     0.116714E 01     0.550000E 01     0.220000E 01
       21     0.3033E 02     0.606600E 01     0.101302E 01     0.730000E 01     0.473000E 01
       22     0.1140E 02     0.228199E 01     0.443233E 00     0.308000E 01     0.185000E 01
       23     0.6639E 01     0.132799E 01     0.649307E-01     0.145000E 01     0.126000E 01
       24     0.1163E 02     0.232599E 01     0.493015E 00     0.330000E 01     0.201000E 01
       25     0.1121E 02     0.224399E 01     0.188000E 00     0.245000E 01     0.190000E 01
       26     0.4494E 02     0.898800E 01     0.315800E 01     0.148000E 02     0.552000E 01
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                              MULTIPLE REGRESSION ANALYSIS
                               PROGRAM REG

 LIEBERMAN - SOURCE 3 - 15MAY72
    NUMBER VARIABLES     =   26

    NUMBER OBSERVATIONS =      8

    GENERAL STATISTICS

    VARIABLE                                    STANDARD                  RANGE
     NUMBER      SUM          AVERAGE          DEVIATION         MAX                  MIN

       1    0.3164E 01    0.395624E 00    0.154058E 00    0.610000E 00     0.200000E 00
       2    0.3328E 02    0.416124E 01    0.374146E 00    0.470000E 01     0.363000E 01
       3    0.1410E 03    0.176337E 02    0.371885E 00    0.180800E 02     0.170600E 02
       4    0.7913E 02    0.989249E 01    0.132615E 01    0.111700E 02     0.751000E 01
       5    0.1175E 03    0.146962E 02    0.642318E 00    0.157500E 02     0.138300E 02
       6    0.6991E 02    0.873999E 01    0.126543E 01    0.103900E 02     0.685000E 01
       7    0.1033E 03    0.129137E 02    0.606835E 00    0.137800E 02     0.117000E 02
       8    0.7829E 02    0.978749E 01    0.631956E 00    0.107900E 02     0.854000E 01
       9    0.7077E 02    0.884749E 01    0.774221E 00    0.992000E 01     0.738000E 01
      10    0.2332E 03    0.291599E 02    0.268537E 01    0.333400E 02     0.255800E 02
      11    0.9774E 02    0.122187E 02    0.545972E 00    0.128900E 02     0.111500E 02
      12    0.7994E 02    0.999374E 01    0.737782E 00    0.110000E 02     0.898000E 01
      13    0.3293E 02    0.411749E 01    0.358425E 00    0.451000E 01     0.335000E 01
      14    0.1648E 03    0.206037E 02    0.102815E 01    0.220000E 02     0.192300E 02
      15    0.1049E 03    0.131174E 02    0.177683E 01    0.159000E 02     0.108000E 02
      16    0.6429E 02    0.803749E 01    0.672565E 00    0.900000E 01     0.690000E 01
      17    0.7691E 02    0.961499E 01    0.147277E 01    0.120000E 02     0.772000E 01
      18    0.5062E 02    0.632750E 01    0.111592E 01    0.900000E 01     0.510000E 01
      19    0.3387E 02    0.423375E 01    0.362592E 00    0.467000E 01     0.360000E 01
      20    0.2062E 02    0.257874E 01    0.485963E 00    0.320000E 01     0.180000E 01
      21    0.2907E 02    0.363499E 01    0.424205E 00    0.425000E 01     0.280000E 01
      22    0.4232E 02    0.529124E 01    0.554874E 00    0.640000E 01     0.429000E 01
      23    0.1389E 02    0.173749E 01    0.124071E 00    0.196000E 01     0.157000E 01
      24    0.1608E 02    0.201124E 01    0.193999E 00    0.237000E 01     0.176000E 01
      25    0.1645E 02    0.205749E 01    0.122040E 00    0.225000E 01     0.180000E 01
      26    0.6310E 02    0.788874E 01    0.123794E 01    0.975000E 01     0.596000E 01
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                         MULTIPLE REGRESSION ANALYSIS
                          PROGRAM REG

LIEBERMAN - SOURCE 4 - 15MAY72
    NUMBER VARIABLES     =   26

    NUMBER OBSERVATIONS =      8

    GENERAL STATISTICS

    VARIABLE                                   STANDARD                RANGE
     NUMBER      SUM          AVERAGE          DEVIATION        MAX              MIN

        1    0.1459E 01    0.182499E 00    0.966630E-01    0.330000E 00    0.700000E-01
        2    0.9800E 01    0.122500E 01    0.203838E 00    0.150000E 01    0.770000E 00
        3    0.1173E 03    0.146699E 02    0.123485E 01    0.159400E 02    0.119000E 02
        4    0.6626E 02    0.828374E 01    0.757791E 00    0.943000E 01    0.726000E 01
        5    0.1202E 03    0.150324E 02    0.163596E 01    0.191800E 02    0.139100E 02
        6    0.5783E 02    0.722999E 01    0.948353E 00    0.687000E 01    0.539000E 01
        7    0.1231E 03    0.153899E 02    0.708078E 00    0.167100E 02    0.142000E 02
        8    0.8276E 02    0.103462E 02    0.528368E 00    0.114800E 02    0.950000E 01
        9    0.6426E 02    0.803374E 01    0.978850E 00    0.994000E 01    0.617000E 01
       10    0.3315E 03    0.414487E 02    0.176346E 01    0.441900E 02    0.395900E 02
       11    0.1069E 03    0.133737E 02    0.463167E 00    0.141000E 02    0.126600E 02
       12    0.6774E 02    0.846874E 01    0.716596E 00    0.101000E 02    0.761000E 01
       13    0.2333E 02    0.291749E 01    0.818317E 00    0.430000E 01    0.159000E 01
       14    0.8279E 02    0.103499E 02    0.278388E 00    0.108000E 02    0.990000E 01
       15    0.8111E 02    0.101399E 02    0.857729E 00    0.121000E 02    0.910000E 01
       16    0.6892E 02    0.861624E 01    0.303477E 00    0.910000E 01    0.810000E 01
       17    0.6842E 02    0.855374E 01    0.384997E 00    0.940000E 01    0.810000E 01
       18    0.5829E 02    0.728749E 01    0.284769E 00    0.780000E 01    0.680000E 01
       19    0.5567E 02    0.695999E 01    0.153948E 00    0.710000E 01    0.668000E 01
       20    0.3426E 02    0.428374E 01    0.300164E 00    0.490000E 01    0.400000E 01
       21    0.4045E 02    0.505749E 01    0.683844E 00    0.600000E 01    0.380000E 01
       22    0.1910E 02    0.238750E 01    0.355026E 00    0.316000E 01    0.193000E 01
       23    0.9309E 01    0.116374E 01    0.102339E 00    0.140000E 01    0.105000E 01
       24    0.1476E 02    0.184624E 01    0.206696E 00    0.222000E 01    0.153000E 01
       25    0.1183E 02    0.147999E 01    0.151904E 00    0.172000E 01    0.119000E 01
       26    0.8199E 02    0.102499E 02    0.482519E 01    0.199000E 02    0.590000E 01
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                         MULTIPLE REGRESSION ANALYSIS
                           PROGRAM REG


LIEBERMAN - SOURCE 6 - 15MAY72
    NUMBER VARIABLES     =   26


    NUMBER OBSERVATIONS =     8


    GENERAL STATISTICS


  VARIABLE                                    STANDARD                 RANGE
   NUMBER      SUM          AVERAGE          DEVIATION          MAX                MIN


         1  -0.8000E 02  -0.100000E 02   0.000000E 00  -0.100000E 02   -0.100000E 02
         2   0.1528E 03   0.191124E 02   0.914213E 01   0.317000E 02    0.800000E 01
         3   0.9168E 02   0.114612E 02   0.131432E 01   0.141100E 02    0.102100E 02
         4   0.5539E 01   0.692499E 00   0.164145E 00   0.100000E 01    0.470000E 00
         5   0.3807E 02   0.475875E 01   0.527907E 00   0.569000E 01    0.421000E 01
         6   0.2189E 01   0.273749E 00   0.849908E-01   0.380000E 00    0.140000E 00
         7   0.1639E 03   0.204924E 02   0.160254E 01   0.228000E 02    0.183800E 02
         8   0.6063E 02   0.757999E 01   0.107456E 01   0.915000E 01    0.600000E 01
         9   0.8157E 02   0.101974E 02   0.250971E 01   0.136100E 02    0.668000E 01
        10   0.4615E 03   0.576974E 02   0.509681E 01   0.636000E 02    0.511000E 02
        11   0.4400E 02   0.550000E 01   0.301382E 01   0.940000E 01    0.250000E 01
        12   0.2881E 02   0.360249E 01   0.735471E 00   0.517000E 01    0.240000E 01
        13   0.2479E 01   0.309999E 00   0.630733E 00   0.195000E 01    0.000000E 00
        14   0.3870E 03   0.483750E 02   0.197024E 01   0.518000E 02    0.453000E 02
        15   0.2226E 03   0.278374E 02   0.561109E 00   0.284000E 02    0.268000E 02
        16   0.1939E 02   0.242499E 01   0.672216E 00   0.410000E 01    0.190000E 01
        17   0.7629E 01   0.953749E 00   0.431536E 00   0.200000E 01    0.600000E 00
        18   0.1589E 01   0.198749E 00   0.188841E 00   0.520000E 00    0.000000E 00
        19   0.7599E 00   0.949999E-01   0.113137E 00   0.300000E 00    0.000000E 00
        20   0.1300E 00   0.162500E-01   0.429934E-01   0.130000E 00    0.000000E 00
        21   0.1300E 00   0.162500E-01   0.429934E-01   0.130000E 00    0.000000E 00
        22   0.7000E 11   0.875000E 10   0.330718E 10   0.100000E 11    0.342000E 01
        23   0.2063E 03   0.257999E 02   0.695611E 01   0.367000E 02    0.143000E 02
        24   0.2735E 02   0.341999E 01   0.608774E 01   0.195000E 02    0.770000E 00
        25   0.8559E 01   0.106999E 01   0.127377E 00   0.121000E 01    0.830000E 00
        26   0.6000E 11   0.750000E 10   0.433012E 10   0.100000E 11    0.105000E 02
```

```
                                     MULTIPLE REGRESSION ANALYSIS
                                      PROGRAM REG

  LIEBERMAN - SOURCE 5 - 15MAY72
     NUMBER VARIABLES      =   26

     NUMBER OBSERVATIONS =       7

     GENERAL STATISTICS

  VARIABLE                                         STANDARD                    RANGE
   NUMBER        SUM           AVERAGE             DEVIATION         MAX                    MIN

      1      0.1439E 01    0.205714E 00     0.627596E-01    0.300000E 00      0.100000E 00
      2      0.1816E 02    0.259571E 01     0.326183E 00    0.292000E 01      0.205000E 01
      3      0.1193E 03    0.170471E 02     0.362362E 00    0.176100E 02      0.165100E 02
      4      0.7065E 02    0.100928E 02     0.733868E 00    0.108300E 02      0.867000E 01
      5      0.9849E 02    0.140714E 02     0.716009E 00    0.151000E 02      0.127000E 02
      6      0.6008E 02    0.858428E 01     0.862966E 00    0.102000E 02      0.762000E 01
      7      0.9271E 02    0.132457E 02     0.564645E 00    0.144900E 02      0.126300E 02
      8      0.7026E 02    0.100385E 02     0.508511E 00    0.106900E 02      0.921000E 01
      9      0.6990E 02    0.998714E 01     0.774185E 00    0.110800E 02      0.865000E 01
     10      0.3354E 03    0.479214E 02     0.969586E 00    0.495400E 02      0.465300E 02
     11      0.5846E 02    0.835285E 01     0.359671E 00    0.881000E 01      0.784000E 01
     12      0.4239E 02    0.605714E 01     0.169513E 00    0.635000E 01      0.580000E 01
     13      0.1482E 02    0.211857E 01     0.918779E 00    0.303000E 01      0.000000E 00
     14      0.9969E 02    0.142428E 02     0.495284E 00    0.147000E 02      0.133000E 02
     15      0.8569E 02    0.122428E 02     0.471645E 00    0.129000E 02      0.114000E 02
     16      0.6129E 02    0.875714E 01     0.315581E 00    0.920000E 01      0.810000E 01
     17      0.5609E 02    0.801428E 01     0.313635E 00    0.830000E 01      0.730000E 01
     18      0.4449E 02    0.635714E 01     0.129362E 00    0.650000E 01      0.610000E 01
     19      0.3899E 02    0.557142E 01     0.166598E 00    0.580000E 01      0.530000E 01
     20      0.2429E 02    0.347142E 01     0.166598E 00    0.370000E 01      0.320000E 01
     21      0.2218E 02    0.316999E 01     0.224181E 00    0.360000E 01      0.290000E 01
     22      0.2985E 02    0.426571E 01     0.368233E 00    0.475000E 01      0.362000E 01
     23      0.9899E 01    0.141428E 01     0.102658E 00    0.164000E 01      0.131000E 01
     24      0.1202E 02    0.171857E 01     0.153383E 00    0.203000E 01      0.153000E 01
     25      0.1427E 02    0.203999E 01     0.860232E-01    0.217000E 01      0.187000E 01
     26      0.8871E 02    0.126742E 02     0.819864E 01    0.318000E 02      0.592000E 01
```

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                          MULTIPLE REGRESSION ANALYSIS
                           PROGRAM REG

LIEBERMAN - SOURCE 7 - 15MAY72
     NUMBER VARIABLES     =    26

     NUMBER OBSERVATIONS =     7

     GENERAL STATISTICS

     VARIABLE                                  STANDARD                  RANGE
      NUMBER      SUM          AVERAGE         DEVIATION       MAX                  MIN


        1     0.4201E 02   0.600285E 01   0.103897E 01   0.820000E 01     0.500000E 01
        2     0.2369E 02   0.338571E 01   0.342338E 00   0.380000E 01     0.267000E 01
        3     0.1371E 03   0.195928E 02   0.188361E 01   0.240700E 02     0.182400E 02
        4     0.6721E 02   0.960142E 01   0.110376E 01   0.119800E 02     0.831000E 01
        5     0.1165E 03   0.166557E 02   0.138884E 01   0.196500E 02     0.150300E 02
        6     0.6227E 02   0.889714E 01   0.139391E 01   0.116800E 02     0.745000E 01
        7     0.8097E 02   0.115685E 02   0.166896E 01   0.129000E 02     0.775000E 01
        8     0.5840E 02   0.834428E 01   0.150067E 01   0.931000E 01     0.485000E 01
        9     0.3954E 02   0.565000E 01   0.112785E 01   0.723000E 01     0.316000E 01
       10     0.2470E 03   0.352900E 02   0.110934E 01   0.372500E 02     0.335700E 02
       11     0.7896E 02   0.112800E 02   0.407010E 00   0.121300E 02     0.108000E 02
       12     0.4193E 02   0.599142E 01   0.434821E 00   0.676000E 01     0.546000E 01
       13     0.1289E 02   0.184285E 01   0.494706E 00   0.281000E 01     0.143000E 01
       14     0.1308E 03   0.186857E 02   0.119931E 01   0.203000E 02     0.169000E 02
       15     0.8130E 02   0.116142E 02   0.589015E 00   0.127000E 02     0.107000E 02
       16     0.4940E 02   0.705714E 01   0.345820E 00   0.760000E 01     0.660000E 01
       17     0.5179E 02   0.740000E 01   0.311677E 00   0.800000E 01     0.700000E 01
       18     0.4489E 02   0.641428E 01   0.356284E 00   0.690000E 01     0.580000E 01
       19     0.4209E 02   0.601428E 01   0.383325E 00   0.680000E 01     0.560000E 01
       20     0.2959E 02   0.422857E 01   0.531075E 00   0.490000E 01     0.340000E 01
       21     0.3240E 02   0.462857E 01   0.755388E 00   0.550000E 01     0.310000E 01
       22     0.2361E 02   0.337428E 01   0.513276E 00   0.454000E 01     0.283000E 01
       23     0.1126E 02   0.160999E 01   0.838365E-01   0.169000E 01     0.145000E 01
       24     0.2643E 02   0.377714E 01   0.159618E 01   0.764000E 01     0.260000E 01
       25     0.1581E 02   0.226000E 01   0.530148E 00   0.351000E 01     0.188000E 01
       26     0.1413E 03   0.201928E 02   0.940943E 01   0.317000E 02     0.915000E 01
```

```
                                   MULTIPLE REGRESSION ANALYSIS
                                    PROGRAM REG

LIEBERMAN - SOURCE 8 - 15MAY72
    NUMBER VARIABLES     =   26

    NUMBER OBSERVATIONS =     8

    GENERAL STATISTICS

    VARIABLE                                        STANDARD                      RANGE
     NUMBER       SUM          AVERAGE              DEVIATION           MAX                  MIN

        1     0.6443E 02     0.805499E 01     0.267535E 00     0.840000E 01     0.770000E 01
        2     0.3239E 02     0.404999E 01     0.248545E 00     0.440000E 01     0.361000E 01
        3     0.1470E 03     0.183787E 02     0.625368E 00     0.199700E 02     0.179000E 02
        4     0.8376E 02     0.104712E 02     0.563547E 00     0.114400E 02     0.955000E 01
        5     0.1330E 03     0.166362E 02     0.676349E 00     0.182600E 02     0.160600E 02
        6     0.7788E 02     0.973624E 01     0.107148E 01     0.115100E 02     0.765000E 01
        7     0.1027E 03     0.128499E 02     0.190065E 00     0.131200E 02     0.126000E 02
        8     0.7968E 02     0.996124E 01     0.475011E 00     0.105600E 02     0.908000E 01
        9     0.5679E 02     0.709999E 01     0.962055E 00     0.814000E 01     0.531000E 01
       10     0.2504E 03     0.313074E 02     0.155222E 01     0.335300E 02     0.283800E 02
       11     0.1000E 03     0.125024E 02     0.462621E 00     0.130500E 02     0.117900E 02
       12     0.6053E 02     0.756749E 01     0.433899E 00     0.838000E 01     0.663000E 01
       13     0.2160E 02     0.270124E 01     0.100102E 01     0.357000E 01     0.930000E 00
       14     0.9209E 02     0.115124E 02     0.351559E 00     0.120000E 02     0.109000E 02
       15     0.7999E 02     0.999999E 01     0.244949E 00     0.105000E 02     0.970000E 01
       16     0.6750E 02     0.843750E 01     0.268967E 00     0.880000E 01     0.780000E 01
       17     0.7399E 02     0.924999E 01     0.683739E 00     0.101000E 02     0.830000E 01
       18     0.5639E 02     0.704999E 01     0.229128E 00     0.750000E 01     0.680000E 01
       19     0.5250E 02     0.656250E 01     0.519464E 00     0.720000E 01     0.580000E 01
       20     0.3337E 02     0.417125E 01     0.491463E 00     0.500000E 01     0.360000E 01
       21     0.3368E 02     0.421000E 01     0.123438E 01     0.500000E 01     0.100000E 01
       22     0.2349E 02     0.293749E 01     0.925996E 00     0.536000E 01     0.229000E 01
       23     0.9330E 01     0.116625E 01     0.689089E-01     0.124000E 01     0.100000E 01
       24     0.2114E 02     0.264374E 01     0.414726E 00     0.342000E 01     0.223000E 01
       25     0.1533E 02     0.191749E 01     0.194148E 00     0.212000E 01     0.148000E 01
       26     0.1470E 03     0.183824E 02     0.159983E 02     0.505000E 02     0.787000E 01
```

```
                         MULTIPLE REGRESSION ANALYSIS
                          PROGRAM REG

LIEBERMAN - REPLICATES FOR SOURCE I
    NUMBER VARIABLES     =   26

    NUMBER OBSERVATIONS =    5

    GENERAL STATISTICS

     VARIABLE                                      STANDARD                RANGE
      NUMBER        SUM          AVERAGE          DEVIATION          MAX                MIN


          1     0.3820E 02    0.763999E 01    0.162480E 00    0.790000E 01      0.740000E 01
          2     0.3029E 02    0.606000E 01    0.436348E 00    0.670000E 01      0.540000E 01
          3     0.1054E 03    0.210859E 02    0.355955E 00    0.216400E 02      0.207900E 02
          4     0.5849E 02    0.116999E 02    0.445376E 00    0.122700E 02      0.111000E 02
          5     0.6388E 02    0.127780E 02    0.366409E 00    0.131800E 02      0.122000E 02
          6     0.4386E 02    0.877199E 01    0.570592E 00    0.947000E 01      0.797000E 01
          7     0.5810E 02    0.116219E 02    0.125124E 00    0.118100E 02      0.114300E 02
          8     0.4030E 02    0.806199E 01    0.923912E-01    0.817000E 01      0.790000E 01
          9     0.4404E 02    0.880800E 01    0.165577E 00    0.904000E 01      0.862000E 01
         10     0.1721E 03    0.344239E 02    0.285528E 01    0.394800E 02      0.311800E 02
         11     0.5606E 02    0.112139E 02    0.457972E 00    0.118800E 02      0.104600E 02
         12     0.3405E 02    0.681199E 01    0.409897E 00    0.739000E 01      0.611000E 01
         13     0.1576E 02    0.315199E 01    0.400469E 00    0.362000E 01      0.250000E 01
         14     0.7310E 02    0.146200E 02    0.256124E 00    0.150000E 02      0.143000E 02
         15     0.5789E 02    0.115799E 02    0.271293E 00    0.119000E 02      0.111000E 02
         16     0.4090E 02    0.817999E 01    0.324961E 00    0.880000E 01      0.790000E 01
         17     0.4099E 02    0.819999E 01    0.275681E 00    0.840000E 01      0.770000E 01
         18     0.3169E 02    0.633999E 01    0.205912E 00    0.660000E 01      0.610000E 01
         19     0.2929E 02    0.585999E 01    0.149666E 00    0.610000E 01      0.570000E 01
         20     0.1660E 02    0.331999E 01    0.160000E 00    0.360000E 01      0.320000E 01
         21     0.1989E 02    0.397999E 01    0.331058E 00    0.460000E 01      0.370000E 01
         22     0.1764E 02    0.352999E 01    0.123935E 00    0.377000E 01      0.345000E 01
         23     0.7000E 01    0.139999E 01    0.252982E-01    0.142000E 01      0.136000E 01
         24     0.1194E 02    0.238999E 01    0.493963E-01    0.245000E 01      0.230000E 01
         25     0.1284E 02    0.256999E 01    0.619677E-01    0.269000E 01      0.253000E 01
         26     0.4371E 02    0.874399E 01    0.215507E 01    0.124000E 02      0.655000E 01
```

APPENDIX E

```
LIEBERMAN - SOURCE I WEATHERED VS UNWEATHERED - 17MAY72
 STEPWISE REGRESSION CASE,   1

     DEPENDENT VARIABLE (Y) IS X 27        F-LEVEL TO ENTER  =  0.100

     STANDARD ERROR OF Y = 0.49792959E 00       F-LEVEL TO REMOVE =  0.010

     INDEPENDENT VARIABLE NUMBERS

        1     2     3     4     5     6     7     8     9    10    11    12    13    14

       15    16    17    18    19    20    21    22    23    24    25    26

   STEP NO    1

     VARIABLE ENTERED        26

     F-LEVEL              0.447

     T-LEVEL              0.669



          STANDARD ERROR OF ESTIMATE  0.51091526E 00

          F RATIO FOR THE REGRESSION  0.44794339E 00

          FRACTION OF EXPLAINED VARIANCE (RSQD)      0.04287

          DETERMINANT OF THE CORRELATION MATRIX      1.00000       P = 0.48

          RESIDUAL DEGREES OF FREEDOM (N-K-1)            10

          CONSTANT TERM  0.00000000E 00
 VARIABLE                          ESTIMATED                                          COVARIA
  NUMBER     COEFFICIENT             ERROR            T-RATIO            F-RATIO     RATIO (R

   26        -0.81320E-02      0.12150E-01          0.669              0.447        0.00

  STEP NO    2

    VARIABLE ENTERED       25

    F-LEVEL              4.909
    T-LEVEL              2.215
```

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```
                 ESTIMATED                                                    COVARIANCE
EFFICIENT          ERROR              T-RATIO            F-RATIO    RATIO (R SQD)

.13484E 01    0.13408E 01             1.005              1.011         0.0000
E    1 COMPLETED

LICATES FOR SOURCE 1
```

```
CALCULATED AND OBSERVED VALUES

                            CHRONOLOGICAL ORDER                                    ERROR MAGNITUDE ORDER
RUN NUMBER          OBSERVED     CALCULATED      OBS-CALC      WT        RUN NUMBER     OBSERVED       OBS-CALC


1000.01000   0.545500E 00   0.541663E 00   0.383670E-02               1108.09000 -0.45450E 00 -0.15409E 00
1000.02000   0.545500E 00   0.418135E 00   0.127364E 00               1105.59000 -0.45450E 00 -0.12694E 00
1000.03000   0.545500E 00   0.592347E 00  -0.468471E-01               1215.51000 -0.45450E 00 -0.62365E-01
1000.04000   0.545500E 00   0.590610E 00  -0.451105E-01               1000.03000  0.54550E 00 -0.46847E-01
1000.05000   0.545500E 00   0.497377E 00   0.481221E-01               1000.04000  0.54550E 00 -0.45110E-01
1218.09000  -0.454500E 00  -0.572624E 00   0.118124E 00               1000.01000  0.54550E 00  0.38367E-02
1108.09000  -0.454500E 00  -0.300400E 00  -0.154099E 00               1000.05000  0.54550E 00  0.48122E-01
1105.59000  -0.454500E 00  -0.327559E 00  -0.126940E 00               1218.01000 -0.45450E 00  0.61423E-01
1218.01000  -0.454500E 00  -0.515923E 00   0.614233E-01               1108.01000 -0.45450E 00  0.71941E-01
1108.01000  -0.454500E 00  -0.526441E 00   0.719418E-01               1218.09000 -0.45450E 00  0.11812E 00
1215.51000  -0.454500E 00  -0.392134E 00  -0.623653E-01               1000.02000  0.54550E 00  0.12736E 00
```

APPENDIX F

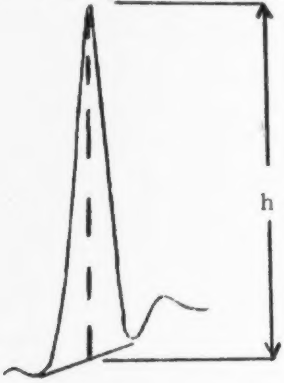
SAMPLE CALCULATIONS FOR GAS CHROMATOGRAM

The calculation procedure used to determine the n-paraffin concentrations in a sample by means of the gas chromatogram involves the following steps.

- Location of n-paraffin peaks by means of a standard run.
- Ascertaining peak areas by peak height x width at half height.*
- Normalization of areas to obtain > C_{20} n-paraffins.

---

* Peak height measured from crest of peak to valley.
e.g.



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